PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-234414

(43)Date of publication of application : 05.09.1995

(51)Int.Cl. G02F 1/1343
G02F 1/133
G02F 1/1333
G02F 1/137

(21)Application number : 06-172935

(22)Date of filing : 25.07.1994

(71)Applicant : TOSHIBA CORP

(72)Inventor : HISATAKE YUZO
SATOU MAKIKO
ISHIKAWA MASAHITO
HADO HITOSHI
OKAMOTO MASUMI
OYAMA TAKESHI

(30)Priority

Priority number : 05184273 Priority date : 27.07.1993 Priority country : JP
05237644 24.09.1993
05335455 28.12.1993 JP

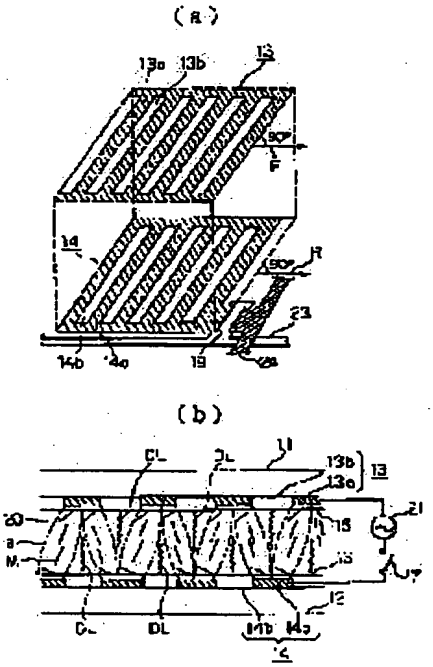
JP

(54) LIQUID CRYSTAL DISPLAY ELEMENT

(57)Abstract:

PURPOSE: To provide an LCD of novel constitution which has a high light scattering characteristic, low driving voltage, bright and high contrast ratio and excellent gradation characteristic, does not invert display in spite of gradation display and is extremely wide in visual field angle.

CONSTITUTION: This liquid crystal display element consists of substrates 11, 12 with electrode arranged to face each other and a liquid crystal layer 20 consisting of a nematic liquid crystal compsn. held between these substrates. At least one of the substrates of the substrates 11, 12 with the electrodes arranged to face each other have the regions consisting of conductor parts 13a, 14a having the electrode structure specified in the width of the widest parts to ≤50μm by each of one pixel and non-conductor parts 13b, 14b specified in the width of the widest part to ≤50μm. The conductor parts 13a, 14a and the non-conductor parts 13b, 14b face each other in at least a part of the regions within the pixels for every one pixel between both substrate 11, 12 disposed opposite to each other; in addition, a relation D≥S/2 is satisfied when the width of the narrowest parts of the non-conductor parts 13b, 14b is defined as S and the spacing between the electrodes of both substrates arranged to face each other as D.



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LEGAL STATUS

[Date of request for examination]	19.07.2001
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3529434
[Date of registration]	05.03.2004
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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CLAIMS

[Claim(s)]
[Claim 1] In the liquid crystal display component which consists of a substrate with an electrode by which opposite arrangement was carried out, and a liquid crystal layer which consists of a pneumatic liquid crystal constituent pinched between this substrate One [at least] substrate of said substrate with an electrode by which opposite arrangement was carried out Electrode structure It is the width of face of the largest part for every pixel. 50 mum Width of face of the conductor section made into the following, and the largest part 50 mum Come to have the field which consists of the non-conductor section made into the following, and it sets among said both substrates by which opposite arrangement was carried out. At least When said conductor section and said non-conductor section have countered in some fields in a pixel for every pixel, and width of face of the narrowest part of said non-conductor section is set to S and the electrode spacing of said both substrates by which opposite arrangement was carried out is set to D, The liquid crystal display component characterized by filling the relation between D>=S/2.
[Claim 2] In a liquid crystal display component according to claim 1, the direction of a tilt at the time of impressing electric field said liquid crystal layer Liquid crystal display component characterized by consisting of a liquid crystal constituent which has the molecular arrangement which can be taken more than a 2-way.
[Claim 3] In a liquid crystal display component according to claim 1, it sets among said both substrates by which opposite arrangement was carried out. Slanting electric field to the direction of a perpendicular normal between both this substrate It is in 1 pixel. It is formed more than a 2-way. The liquid crystal molecule which forms said liquid crystal layer is the degree of freedom of a tilt rise or the tilt down direction in nothing and an electrical-potential-difference impression condition about a spray array at electrical-potential-difference the condition of not impressing. Liquid crystal display component characterized by being the molecular arrangement which can be taken more than a 2-way.
[Claim 4] In the liquid crystal display component of claim 1 thru/or claim 3 given in any 1 term one [said / by which opposite arrangement was carried out / at least] substrate with an electrode The width of face of said largest part 30 mum It is the following. Said pneumatic liquid crystal constituent It has the means which carries out induction of the tilt orientation made to arrange in the direction of liquid crystal molecule major-axis - on said substrate front face. The crossed axes angle of the direction of liquid crystal molecular arrangement on two substrates is set to theta (0 " <= theta<=90 degrees). Above psi is **theta (here, when the twist direction is left-handed rotation and it is + and right-handed rotation, it considers as -.) in the condition of setting to psi the cel twist angle it is decided that carries out the uniform twist array of the liquid crystal, and not impressing electric field to said liquid crystal layer with the pre tilt angle on a two substrates front face. The liquid crystal display component characterized by solving and for the twist angle omega of liquid crystal being **theta+180" or ** theta-180 ", and the liquid crystal twist angle omega being **theta (above, double sign same order) when Above psi is ** (theta-180 ").
[Claim 5] In the liquid crystal display component of claim 1 thru/or claim 4 given in any 1 term said both substrates by which opposite arrangement was carried out When the cross-section configuration in the direction of a component normal of said both substrates electrode is seen, the width of face which has the conductor section only in a bottom substrate RE, FE and both substrates the width of face which is the conductor section about the width of face which has the conductor section only in an upper substrate And EE, When both substrates set to SS width of face which is the non-conductor section and RE and FE at least are electrically connected with one for every pixel in somewhere whose each is a pixel, [whether it is the electrode structure used as RE-SS-FE-SS-RE-SS-FE-SS and --, and the cross-section configuration by which RE and FE are arranged by turns in order on both sides of SS, and] [whether it is the electrode

structure used as RE-EE-FE-EE-RE-EE-FE-EE and --, and the cross-section configuration by which RE and FE are arranged by turns in order on both sides of EE, and] It is the electrode structure used as RE-FE-RE-FE-RE-FE-RE-FE and --, and the cross-section configuration by which RE and FE are arranged by turns in order. Or said pneumatic liquid crystal constituent It has the means which carries out induction of the tilt orientation which makes an one direction arrange a liquid crystal molecule major axis on said substrate front face. The crossed axes angle of the direction of liquid crystal molecular arrangement on two substrates is theta (0 " <= theta<=90 degrees). in the condition of the cel twist angle it is decided in the tilt orientation on a two substrates front face that carries out the uniform twist array of the liquid crystal constituent being the liquid crystal display component which is psi, and not impressing electric field to a liquid crystal constituent Above psi is **theta (when the twist direction is left-handed rotation here and it is + and right-handed rotation, it considers as -.). The liquid crystal display component characterized by solving and for the twist angle omega of liquid crystal being **theta+180 ** or **theta-180 **, and the twist angle omega of liquid crystal being **theta (above double sign same order) when Above psi is ** (theta-180 **).

[Claim 6] In the liquid crystal display component of claim 1 thru/or claim 5 given in any 1 term When said liquid crystal constituent consists of liquid crystal which has a forward or negative dielectric constant anisotropy and impresses electric field, it can be taken. The direction of a tilt more than a 2-way In the case of the liquid crystal which has said forward dielectric constant anisotropy, are the tilt rise direction, in the case of the liquid crystal which has said negative dielectric constant anisotropy, are the tilt down direction, and the liquid crystal molecular arrangement in said both substrates Difference of the pre tilt angle of liquid crystal The liquid crystal molecular arrangement and the pre tilt angle alpha 0 which are made into 0.5 degrees or less The liquid crystal molecular arrangement or the pre tilt angle alpha 0 which consists of perpendicular orientation which is both 90 degrees It is 45 degrees or more both less than 90 degrees. And the difference of the pre tilt angle of a vertical substrate It is 0.5 degrees or less and is said pre tilt angle alpha 0. Liquid crystal display component characterized by being any one liquid crystal molecular arrangement which the direction to acquire becomes from the orientation of the shape of a bend which is the same direction by the upper and lower sides.

[Claim 7] The liquid crystal display component characterized by the electrode structure in every pixel serving as the stripe-like configuration where said both substrates consist of the conductor section and the non-conductor section at least by the part which is each pixel, in the liquid crystal display component of claim 1 thru/or claim 6 given in any 1 term.

[Claim 8] The liquid crystal display component characterized by making the particle which has a diameter shorter than an electrode spacing D in said both substrates gap mix in the liquid crystal display component of claim 1 thru/or claim 7 given in any 1 term, or coming to prepare a projection shorter than an electrode spacing D at least in one side of said both substrates.

[Claim 9] In the liquid crystal display component of claim 1 thru/or claim 8 given in any 1 term, a translucency protective coat is formed on said electrode, and the refractive index of this translucency protective coat is a refractive index of said electrode material. 0.9-1.1 Liquid crystal display component characterized by being twice.

[Claim 10] A liquid crystal display component, the means which carries out incidence of the parallel light to this liquid crystal display component, and a means to control said parallel light by which incidence was carried out by said liquid crystal display component, It is the liquid crystal display which is a projection mold liquid crystal display which consists of a means using the optical system which projects the light of some directions among the travelling directions of said controlled light, and is characterized by said liquid crystal display component being a liquid crystal display component of claim 1 thru/or claim 9 given in any 1 term.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the liquid crystal display using a new liquid crystal display component and new it.
[0002]
[Description of the Prior Art] In recent years, the liquid crystal display component (the following, LCD, and abbreviated name) is widely used for a word processor, a personal computer, the projection mold TV, small TV, etc. Such LCD displays by controlling change of the light and darkness of light. As the control approach of such a light, a color is added to the approach by the combination of the polarization effectiveness of a liquid crystal molecule, and a polarizer, the approach according to dispersion and transparency of light using the phase transition of liquid crystal, and liquid crystal, and there is a method of using shade change of the color produced by controlling the light absorbed amount of a color etc.
[0003] LCD using the approach which combined the polarization effectiveness and a polarizer is the Twisted Nematic (TN) mold LCD with the molecular arrangement twisted 90 degrees, for example, and can control polarization by thin liquid crystal thickness and the low battery theoretically. For this reason, the TN mold LCD shows a high contrast ratio property with a rapid-response rate and a low power. This TN mold LCD is applied to the liquid crystal TV of a full color display etc. by the passive-matrix drive combining the active-matrix drive and color filter which possess a switching element for every pixel on a clock, a calculator, etc. again. However, since a principle top polarizing plate is used for LCD which combined these polarization effectiveness and a polarizer, the amount of transmitted lights of LCD becomes remarkably low. That is, it is even if few. In order to use one polarizing plate, the amount of transmitted lights becomes at least 50% or less. Moreover, since a foreground color and a contrast ratio change with the include angle and bearings seen by the bearing nature of liquid crystal molecular arrangement a lot, it has a viewing-angle dependency. In addition to this viewing-angle dependency, for the reasons nil why the permeability shown by the ratio of the amount of transmitted lights to the amount of incident light is low etc., by the time the TN mold LCD exceeds completely the display engine performance of a cold cathode-ray tube (CRT), the actual condition will not have resulted.
[0004] On the other hand, LCD using the phase transition of liquid crystal and LCD which controlled the light absorbed amount of a color are LCD using the White Taylor mold GH liquid crystal which comes to add a color in PC mold liquid crystal which produces the phase transition to the nematic phase which has the molecular arrangement of HOMEOTORO pick structure from a cholesteric phase with the molecular arrangement of for example, helical structure in electric-field impression, and this liquid crystal molecule etc. Since such LCD does not use a principle top polarizing plate, permeability does not become low. Moreover, since a large check-by-looking angle is shown, it is applied to Jidosha Kiki, a projection mold drop, etc.
[0005] However, unless such LCD does not make liquid crystal thickness comparatively thick, or it is sufficient in slight strength and carries out helical reinforcement of a liquid crystal molecule, dispersion of sufficient light is not acquired. This is because various liquid crystal molecular arrangement therefore requires dispersion of light. That is, in order to fully scatter light, in the case of a cholesteric phase with the molecular arrangement of for example, helical structure, the need of having a helical shaft in all bearings arises to the direction of incident light. Thus, in order to give the helical shaft of much bearings, liquid crystal thickness must be thickened. For this reason, such LCD required high driver voltage, and had the problem that a speed of response was very slow, and the application to a display device with many amounts of displays (pixel number) was difficult. Moreover, the gradation display was also difficult in order that

permeability might change rapidly with the increment in applied voltage. Furthermore, since the molecular arrangement of liquid crystal differs remarkably in the state of a light-scattering condition and light transmission, when performing phase tautomerization-ization of light scattering and a light transmission condition by electric-field control, a hysteresis will arise in the electro-optics property. Although various views are one of the causes which this hysteresis produces and it does not clarify, it is known that it will be easy to generate when the molecular arrangement of liquid crystal differs remarkably, or when the liquid crystal molecule forms the light-scattering condition (condition that the molecular arrangement of liquid crystal serves as the aggregate of a detailed domain), in the condition that electric field are not impressed. Thus, when the hysteresis was in the impression electric-field-transmission property, that a multiplexer drive becomes difficult etc. had a problem practical.

[0006] LCD using a means (generally it is called the DS effectiveness) to acquire light scattering, or a means to acquire light scattering by the thermooptic effect is proposed by impressing the high voltage to other LCD using the phase transition of liquid crystal by low frequency using Nn liquid crystal which dissolved conductive matter, such as an organic electrolyte. However, there is an above-mentioned problem also in this case.

[0007] Furthermore, as shown in drawing 36 (a), many capsules are formed in a substrate 1 and the polymer 3 pinched among two, and as shown in the capsule-like structure which enclosed liquid crystal 4 into this, and drawing 36 (b), the macromolecule distributed process input output equipment LCD which raises light-scattering nature using the fibrous polymer structure where liquid crystal 6 was distributed, between the fibrous polymers 5 is proposed. However, such macromolecule distributed process input output equipment LCD has constraint in the configuration of the polymer, or the mixing ratio of a polymer and a liquid crystal layer from on a process and a principle. Moreover, since the partial pressure of the electrical potential difference impressed from the outside is carried out to a polymer and liquid crystal, a part of applied voltage is impressed to liquid crystal. For this reason, when it is going to satisfy the drive property that driver voltage low enough, a high speed of response, etc. are required, the present condition is being unable to obtain sufficient light-scattering nature. Moreover, also in these methods, since the molecular arrangement of liquid crystal differs remarkably in the state of a light-scattering condition and light transmission, as mentioned above, a hysteresis will arise in an electro-optics property. On the other hand, although it is possible to control liquid crystal molecular arrangement in a light-scattering condition to some extent (for example, for the hydrophobic matter to be mixed to a polymer in order to control the liquid crystal molecular arrangement in a capsule inside), and to also make said hysteresis mitigate, this will weaken light scattering to coincidence and is not practical. Thus, also in macromolecule distributed process input output equipment LCD, there was the same problem as other LCD using the phase transition of liquid crystal.

[0008] Orientation processing is performed for every detailed field so that a liquid crystal molecule may be made to arrange [in / as technique over which light is scattered / the front face of two substrates with an electrode] in the various directions, and also making the gap which these were made to counter as an inside pinch liquid crystal is considered. However, it does not become a means by which changing the orientation processing direction (for example, the direction of rubbing) for every detailed field solves the problem of the above-mentioned hysteresis difficult in practice.

[0009]

[Problem(s) to be Solved by the Invention] As mentioned above, the conventional LCD has low permeability, and has a narrow viewing-angle dependency, or required high driver voltage, and had the problem that a speed of response was also slow. This invention was made in order to cope with such a technical problem, its light-scattering property is high, and its driver voltage is low, and it is [it is bright, and a contrast ratio is high, and] excellent in gradation nature, and even if it indicates by gradation, it aims at a display not being reversed and offering LCD of the very large new configuration of an angle of visibility.

[0010]

[Means for Solving the Problem] as a means by which LCD of this invention scatters light -- media other than liquid crystal -- not needing -- in addition -- and in the state of a light transmission condition and light scattering, the molecular arrangement of liquid crystal does not differ remarkably, but considers as the configuration which can acquire a good light-scattering condition. Furthermore, it is also the configuration that it cannot be based on a complicated production process, but LCD can be manufactured.

[0011] LCD of this invention consists of a substrate with an electrode by which opposite arrangement was carried out, and a liquid crystal layer which consists of a pneumatic liquid crystal constituent pinched between this substrate. One [at least] substrate of the substrate with an electrode by which opposite

arrangement was carried out Electrode structure It is the width of face of the largest part for every pixel. 50 mum Width of face of the conductor section made into the following, and the largest part 50 mum In between both the substrates by which opposite arrangement was carried out by coming to have the field which consists of the non-conductor section made into the following At least When the conductor section and the non-conductor section have countered in some fields in a pixel for every pixel, and width of face of the narrowest part of the non-conductor section is set to S and the electrode spacing of both the substrates by which opposite arrangement was carried out is set to D, it is D>=S/2. It is characterized by filling relation.
[0012] In this LCD, the direction of a tilt at the time of impressing electric field a liquid crystal layer It is characterized by consisting of a liquid crystal constituent which has the molecular arrangement which can be taken more than a 2-way. Moreover, slanting electric field to the direction of a perpendicular normal between both this substrate among both the substrates by which opposite arrangement was carried out It is in 1 pixel. The liquid crystal molecule which is formed more than a 2-way and forms a liquid crystal layer is the degree of freedom of a tilt rise or the tilt down direction in nothing and an electrical-potential-difference impression condition about a spray array at electrical-potential-difference the condition of not impressing. It is characterized by being the molecular arrangement which can be taken more than a 2-way.
[0013] Concretely one [at least] substrate with an electrode with which opposite arrangement of this invention was carried out The width of face of the largest part 30 mum It is the following. A pneumatic liquid crystal constituent It has the means which carries out induction of the tilt orientation made to arrange in the direction of liquid crystal molecule major-axis - on a substrate front face. The crossed axes angle of the direction of liquid crystal molecular arrangement on two substrates is set to theta (0 " <= theta<=90 degrees). psi is **theta (here, when the twist direction is left-handed rotation and it is + and right-handed rotation, it considers as -.) in the condition of setting to psi the cel twist angle it is decided that carries out the uniform twist array of the liquid crystal, and not impressing electric field to a liquid crystal layer with the pre tilt angle on a two substrates front face. It solves and the twist angle omega of liquid crystal is **theta+180" or ** theta-180 ", and when psi is ** (theta-180 "), it is characterized by the liquid crystal twist angle omega being **theta (above, double sign same order).
[0014] Moreover, both the substrates by which opposite arrangement was carried out as other examples of this invention When the cross-section configuration in the direction of a component normal of both the substrates electrode is seen, the width of face which has the conductor section only in a bottom substrate RE, FE and both substrates the width of face which is the conductor section about the width of face which has the conductor section only in an upper substrate And EE, When both substrates set to SS width of face which is the non-conductor section and RE and FE at least are electrically connected with one for every pixel in somewhere whose each is a pixel, [whether it is the electrode structure used as RE-SS-FE-SS-RE-SS-FE-SS and --, and the cross-section configuration by which RE and FE are arranged by turns in order on both sides of SS, and] [whether it is the electrode structure used as RE-EE-FE-EE-RE-EE-FE-EE and --, and the cross-section configuration by which RE and FE are arranged by turns in order on both sides of EE, and] It is the electrode structure used as RE-FE-RE-FE-RE-FE-RE-FE and --, and the cross-section configuration by which RE and FE are arranged by turns in order. Or a pneumatic liquid crystal constituent It has the means which carries out induction of the tilt orientation which makes an one direction arrange a liquid crystal molecule major axis on a substrate front face. The crossed axes angle of the direction of liquid crystal molecular arrangement on two substrates is theta (0 " <= theta<=90 degrees). psi is **theta (when the twist direction is left-handed rotation here and it is + and right-handed rotation, it considers as -.) in the condition of the cel twist angle it is decided in the tilt orientation on a two substrates front face that carries out the uniform twist array of the liquid crystal constituent being the liquid crystal display component which is psi, and not impressing electric field to a liquid crystal constituent. It solves and the twist angle omega of liquid crystal is **theta+180 ** or **theta-180 **, and when psi is ** (theta-180 **), it is characterized by the twist angle omega of liquid crystal being **theta (above double sign same order).
[0015] As the liquid crystal constituent concerning this invention, and liquid crystal molecular arrangement When a liquid crystal constituent consists of liquid crystal which has a forward or negative dielectric constant anisotropy and impresses electric field, it can be taken. The direction of a tilt more than a 2-way In the case of the liquid crystal which has a forward dielectric constant anisotropy, are the tilt rise direction, in the case of the liquid crystal which has a negative dielectric constant anisotropy, are the tilt down direction, and the liquid crystal molecular arrangement in both substrates Difference of the pre tilt angle of liquid crystal The liquid crystal molecular arrangement and the pre tilt angle alpha 0 which are made into 0.5 degrees or less The liquid crystal molecular arrangement or the pre tilt angle alpha 0 which consists of perpendicular orientation which is both 90 degrees It is 45 degrees or more both less than 90 degrees. And

the difference of the pre tilt angle of a vertical substrate It is 0.5 degrees or less and is said pre tilt angle alpha 0. It is characterized by being any one liquid crystal molecular arrangement which the direction to acquire becomes from the orientation of the shape of a bend which is the same direction by the upper and lower sides.
[0016] It is characterized by the electrode structure concerning this invention and the electrode structure in every pixel serving as the stripe-like configuration where both substrates consist of the conductor section and the non-conductor section at least by the part which is each pixel. Furthermore, said one [at least] substrate with an electrode It is desirable to have a switching element for every pixel.
[0017] LCD of this invention makes the particle which has a diameter shorter than an electrode spacing D mix in both the substrates gap, or is characterized by coming to prepare a projection shorter than an electrode spacing D at least in one side of said both substrates. Furthermore, a translucency protective coat is formed on an electrode and the refractive index of this translucency protective coat is a refractive index of an electrode material. 0.9-1.1 It is characterized by being twice.
[0018] The liquid crystal display of this invention is a projection mold liquid crystal display which consists of a means using the optical system which projects the light of some directions among the means which carries out incidence of the parallel light to LCD, a means to control by LCD this parallel light by which incidence was carried out, and the travelling direction of the controlled light, and is characterized by using LCD of above-mentioned this invention as LCD.
[0019] furthermore, LCD of this invention two or more -- using -- respectively -- alike -- red -- blue and green -- at least -- either or it carries out incidence of the parallel light containing one color by which the spectrum was carried out -- or -- By providing the color filter of two or more colors in one LCD, it is desirable to carry out color display.
[0020]
[Function] LCD of this invention controls light by the new liquid crystal cell configuration. Hereafter, the principle which controls light in this invention is explained. LCD of this invention considers as uniform molecular arrangement effectually in each pixel -- a light transmission condition -- realizing -- moreover -- It has two or more sorts of directions of electric field, and a light-scattering condition is realized by acquiring the dioptric lens effectiveness and the diffraction-grating effectiveness. Here, the dioptric lens effectiveness means the effectiveness of making the light which carried out incidence refracted, when a liquid crystal molecule changes an inclination in the direction of liquid crystal thickness continuously and the refractive index of a liquid crystal layer changes continuously. Moreover, the diffraction-grating effectiveness is the extraordinary index ne of a liquid crystal molecule. Tsunemitsu refractive index no By appearing by turns regularly in a liquid crystal flat surface, a diffraction grating is formed in a liquid crystal layer, and the effectiveness that parallel light is scattered about as a result is said. It is obtained by forming Wall (wall)-like molecular arrangement in the boundary section of light scattering by such dioptric lens effectiveness or the diffraction-grating effectiveness, and two or more sorts of directions of electric field.
[0021] An example of the molecular arrangement structure in 1 pixel of LCD of this invention is shown in drawing 1 (b). the molecular arrangement by which the molecular arrangement structure shown in this drawing 1 (b) added the twist to a spray array and it -- it is -- in addition -- and the liquid crystal molecule pre tilt angle in a vertical substrate front face is characterized by the almost equal thing by the upper and lower sides. Moreover, the molecular arrangement structure at the time of impressing an electrical potential difference is shown. that is, a top, the electrodes 13 and 14 which form two or more stripes in a pixel unit in the bottom substrates 11 and 12, respectively are arranged, and the current carrying parts 13a and 14a and the non-current carrying parts 13b and 14b of each electrode are made into regular intervals -- it carries out [1 / / 2 pitch **], and is made to counter The direction of orientation of the bottom orientation film 15 and 16 is made into the same direction a top, and the liquid crystal molecule M of the liquid crystal layer 20 is considered as the spray array.
[0022] If an electrical potential difference is impressed to the vertical electrodes 13 and 14, the longitudinal direction electric field e will occur. As [illustrate / depending on the method of impression of electric field / in such molecular arrangement / the direction of a tilt of the molecule] It becomes a 2-way. This requires the liquid crystal molecular arrangement in the condition of not impressing an electrical potential difference for having a symmetrical form an upper half and in the lower half of a liquid crystal layer. getting it blocked -- the direction of a tilt of a liquid crystal molecule two or more degrees of freedom -- **** -- it is because it is. Therefore, the boundary section (inside DL of drawing) of the direction of a tilt of a molecule can be made to generate Wall Rhine (for "Wall" to be called in this invention, in order to distinguish from the disclination in the strong general semantics of the memory nature which is generated at the time of electric-

field impression and to generate.), and the function to scatter incident light can be obtained so that it may illustrate, if an electrical potential difference is impressed. Thus, the direction of a tilt of a liquid crystal molecule The effectiveness same also as a perfect perpendicular array that a pre tilt angle [in / for liquid crystal molecular arrangement / a vertical substrate] is 90 degrees can be acquired using the pneumatic liquid crystal constituent which has a negative dielectric constant anisotropy for giving two or more degrees of freedom as other, for example, liquid crystal, constituents [structure / molecular arrangement] of drawing 1 (b). In this case, the degree of freedom of the tilt down direction of a liquid crystal molecule It becomes two or more.

[0023] Anyway, in this way, in the condition of not impressing the electrical potential difference, a liquid crystal molecule is uniform molecular arrangement effectually, and the degree of freedom of the tilt rise direction of a liquid crystal molecule or the tilt down direction Slanting electric field conflict for every detailed field to the liquid crystal molecular arrangement which is two or more. If it is the electrode it was considered that it was impressed more than a 2-way, the outstanding display engine performance which solved the problem mentioned above can be obtained.

[0024] In order to realize slanting electric field effectively here, when it sets width of face of the narrowest part of the non-conductor section to S and the electrode spacing of both the substrates by which opposite arrangement was carried out is set to D, it is D>=S/2. It becomes a requirement that relation is filled. Hereafter, drawing 2 explains the reason. Drawing 2 is one sectional view of electrode structure used for this invention. In drawing 2 , the weakest electric field are Es and this field strength determines the strength of slanting electric field. And the array of the liquid crystal molecule which affects the dioptric lens effectiveness and the diffraction-grating effectiveness with the magnitude of this slanting field strength is controlled. The field strength of Es is Ev as a result of an experiment. (2)1/2/2 It turned out that optical control can be carried out effectively at the following. Therefore, Es>= For (2) 1/2 / 2 Ev serving as a requirement, and realizing this, it is D>=S/2. It becomes. If D and S are set up in this range, the liquid crystal molecule in the field of S is also controlled by electric field in need 10 minutes, and can control the direction of a tilt, and array bearing.

[0025] This invention heightens the light-scattering effectiveness by the existence of applied voltage with a horizontal electric-field component using the sense of a liquid crystal molecule changing, when not carrying out the uniform twist array of the liquid crystal. For this reason, the conductor section and the non-conductor section are formed in the minute field of an electrode, while carries out phase opposite and the amount of [of the conductor section of an electrode and the electrode of another side] non-conductor is made to meet on both sides of a liquid crystal layer between substrates.

[0026] As a premise explaining an operation of this invention, a pre tilt angle, a uniform twist array, and a non-uniform twist array are described. The molecule of a pneumatic liquid crystal is making the shape of a long and slender rod. If a liquid crystal molecule touches the orientation film which carried out rubbing on the substrate, the major axis of the cylindrical molecule will carry out orientation in the fixed direction with the property of an orientation film front face. For example, along the direction where the orientation film carried out rubbing of the case of the polyimide orientation film etc., a liquid crystal molecule major axis is located in a line, and orientation is carried out. Moreover, in the case of the polystyrene orientation film etc., in the direction of a film flat surface, a liquid crystal molecule major axis is located in a line in the direction of rubbing in the right-angled direction. Moreover, there is the approach of vapor-depositing the orientation film to a substrate as the approach of another orientation processing. If oxidation silicon is vapor-deposited from across at 85 degrees of incident angles to a substrate side, the major axis of a liquid crystal molecule will be suitable in the direction of the source of vacuum evaporationo.

[0027] However, in practice, in these orientation processings, orientation of the liquid crystal molecule M is not carried out in parallel with the orientation film surface S, but it is [as opposed to / like drawing 3 (a) / the orientation film surface S i.e., a substrate side,] a certain predetermined include angle alpha 0 by tilt orientation. Orientation is risen and carried out. This include angle alpha 0 It is abbreviation with the polyimide orientation film. It is 1-15 degrees. Angle alpha 0 with the major axis LA of the liquid crystal molecule which touches a substrate side on this substrate side to make It is called a pre tilt angle. If the edge which approaches a leading part L and substrate side in the edge which rose from the substrate of the liquid crystal molecule major axis LA is used as the trailing part T at this time as shown in drawing 3 (a), suppose that the arranged liquid crystal molecule M is expressed with the arrow head R from T to the direction of L on an orientation film flat surface like drawing 3 (b) on explanation.

[0028] the case where orientation processing is carried out so that the molecular arrangement of the rear substrate 12, i.e., a bottom substrate, may be set to R (arrow head of a broken line) in the example of

drawing 4 (a), as the molecular arrangement of the front substrate 11, i.e., an upper substrate, is set to F (arrow head of a continuous line) -- it is -- each array -- a substrate flat-surface top -- hard flow -- namely, -- It is suitable in the direction different 180 degrees. In this configuration, if a dielectric constant anisotropy in which a liquid crystal molecule does not have a twist is filled up with a forward pneumatic liquid crystal (for example, chiral agent un-mixing), it will arrange at a fixed and uniform include angle like drawing 4 (b) covering the thickness overall length of the liquid crystal layer 20, liquid crystal covering [M] it over the bottom substrate 12 from the upper substrate 11. Generally, such molecular arrangement is called uniform array and it is the fundamental configuration of the conventional LCD. If impressed to a liquid crystal layer, the electrical potential difference, i.e., the driver voltage, more than threshold voltage, in LCD of this configuration, the liquid crystal molecule M will arrange uniformly in the almost perpendicular direction to a substrate according to the direction to which the liquid crystal molecule near both the substrates front face inclines like drawing 5 .

[0029] angle theta (<=90 degree) Drawing 6 is drawing supposing the case in the condition of having twisted, about the bottom substrate 12 on the basis of the condition of drawing 4 (a) to the upper substrate 11. What is necessary is for liquid crystal to take the array to which only angle psi was twisted in the counterclockwise direction (hand of cut of the drawing Nakaya mark) among both substrates, and just to select a liquid crystal ingredient so that only angle psi may be twisted to realize this in order for the molecular arrangement at this time to maintain a uniform array. Thus, the obtained molecular arrangement can be called the twisted uniform array, and calls this angle psi the twist angle of a uniform array in this case. ST-LCD which is incidentally the conventional technique is carrying out the twisted uniform array which made this psi 90 degrees - 270 ".

[0030] Drawing 7 is psi. The relation of the permeability of LCD to the applied voltage in ST-LCD which is 180 degrees is shown. ST-LCD will change permeability from this drawing steeply above a certain electrical potential difference Vth, i.e., threshold voltage. From this, it is thought that LCD of ST mold is making the molecular arrangement near electrical-potential-difference the condition of not impressing, under the applied voltage below threshold voltage, and the twist angle of liquid crystal is 90 degrees or more like this ST-LCD. When defining the molecular arrangement of LCD 270 degrees or less, it will define by the bottom of the applied-voltage condition below this threshold voltage (at the time of no impressing). Moreover, in such a permeability-applied-voltage property (curve of drawing 7), the difference of the applied-voltage value which generally becomes 90% of permeability and 10% about the steepness of the property is expressed with the value gamma broken by the value of the applied voltage of 90% of permeability. In LCD of this configuration, if the electrical potential difference more than threshold voltage is impressed to a liquid crystal layer like the case of a uniform array without the twist mentioned above (at the time of electrical-potential-difference impression), as the liquid crystal molecule M twisted the array of drawing 5 according to the direction to which the liquid crystal molecule near both the substrates front face inclines, it will arrange in the almost perpendicular direction to a substrate.

[0031] drawing 6 shows -- as -- the twist angle psi of a uniform array -- trailing part TF of the liquid crystal molecule of the orientation F of an upper substrate criteria -- carrying out -- leading part LR of the liquid crystal molecule of the orientation R of a bottom substrate up to -- the include angle is expressed. psi is [+theta and] -theta about right-handed rotation like drawing 8 in left-handed rotation like drawing 6 . It can be defined as two kinds.

[0032] On the other hand, the array of a liquid crystal molecule like drawing 9 (b) is also possible. Such an array can be attained if the pneumatic liquid crystal constituent which does not produce a twist is maintained under the configuration of drawing 9 (a) like the array of drawing 4 (b) mentioned above.

[0033] such molecular arrangement -- the molecular arrangement F and R of a vertical substrate -- this direction -- it is -- drawing 9 (b) -- like -- molecular arrangement -- the tilt angle of a liquid crystal molecule -- pre tilt angle alpha 0 of the upper substrate 11 from -- gradually -- an include angle -- decreasing -- middle point d / 2 of the liquid crystal thickness d Pre tilt angle alpha 0 of the bottom substrate 12 after becoming parallel to a substrate 11 It inclines to the reverse include angle until it results. Namely, leading parts LF and LR It approaches mutually and they are the trailing parts TF and TR. It separates mutually and arranges. Such a non-uniform array is called spray array.

[0034] Below, it considers acquiring the structure which added the twist like the uniform array mentioned above in this spray array. considering considering orientation R of the bottom substrate 12 as a spray array as well as the uniform array of drawing 6 to the orientation F of the upper substrate 11, like drawing 10 , after only theta has crossed, it is shown in drawing 10 -- as -- trailing part TF of the orientation F of the upper substrate 11 from -- trailing part TR of the orientation R of a bottom substrate The liquid crystal

molecule must be twisted at the include angle to make. since omega is negative when spray array twist angle omegaL becomes (theta+180 ") and omega is taken in the clockwise direction, since omega is forward when omega will be taken in the counterclockwise direction [of drawing 10], if this twist angle in a spray array is set to omega -- spray array twist angle omegaR -- that supplementary angle -- it is (theta-180 ") -- it becomes. moreover -- since omega is forward when spray array twist angle omegaR becomes (- theta-180 ") and omega is taken in the counterclockwise direction, since omega is negative when considering a configuration like drawing 11 omega is taken in the clockwise direction -- spray array twist angle omegaL -- the supplementary angle -- it is (-theta+180 degrees) -- it becomes.

[0035] Thus, by drawing 10 and the configuration of 11, it is the spray array twist angle omega ((**theta+180 **) **theta-180 **). Either of four kinds of twist conditions can be taken. Also in a spray array, a twist array is realizable corresponding to +theta of the twist angle psi at the time of a uniform array, and -theta, respectively as mentioned above.

[0036] Considering the twist angle psi at the time of carrying out a uniform twist array, each omega explained by drawing 10 and drawing 11 is set to psi=+theta and -theta, respectively, and angle theta In the range which is 0<=theta<=90 degrees In order to realize the spray array twisted when psi was **theta, the twist angle omega means not being materialized, respectively (**theta+180 **), if it is not (**theta-180 **). In this case, the range of the value which omega can take serves as omega=|theta**180 **|=90 degree- 270", and its twist angle of this corresponds with the practical use solution of conventional ST-LCD. that is, -- if it is the twisted spray array and considers acquiring a twist angle equal to the twist angle of conventional ST-LCD -- the twist angle psi of a uniform array -- **theta -- it is -- the twist angle omega of liquid crystal -- it becomes [or / (**theta-180 **) / (**theta+180 **)]. This configuration serves as the 1st description of LCD of this invention. Such a spray array becomes in the direction where the liquid crystal molecules of the front face of an upper substrate and each bottom substrate have the reverse direction (the direction of a pre tilt) to which the liquid crystal molecule in a vertical substrate front face inclines. Therefore, when it sees in the whole liquid crystal layer, the direction of a tilt of the liquid crystal molecule when impressing an electrical potential difference is because of depending in the direction of a tilt of an upper substrate or a bottom substrate front face. There will be two kinds. For this reason, slanting electric field When impressed in the direction of two kinds, a liquid crystal molecule is . A tilt can be carried out in the direction of two kinds, and the light-scattering effectiveness which is the effectiveness of this invention can be acquired easily.

[0037] Since the direction of a pre tilt also serves as a vertical substrate with the same direction effectually when said uniform array is used on the contrary, it is a molecular arrangement top. Only one kind of direction of a tilt can be acquired. For this reason, liquid crystal molecule In order to make a tilt carry out in the direction of two kinds, it is necessary to impress very strong slanting electric field, and is not practical. In a uniform array, according to an artificer's etc. experimental result, if the electrical potential difference beyond 60V is not impressed by the electrode configuration of this example, either, the light-scattering effectiveness by Wall is not acquired.

[0038] Thus, the direction of a tilt of a liquid crystal molecule on liquid crystal molecular arrangement The thing used as two kinds is the following besides an above-mentioned spray array. They are two kinds. One is the pre tilt angle alpha 0 of a vertical substrate. It is the liquid crystal molecular arrangement of the perfect perpendicular orientation which is both 90 degrees. In this case, the ingredient of a negative dielectric constant anisotropy is used as a liquid crystal constituent. If an electrical potential difference is impressed to the liquid crystal constituent in which this negative dielectric constant anisotropy is shown, the tilt of the liquid crystal molecule will be carried out in the direction of electric field, and the direction which intersects perpendicularly. therefore, the electrode configuration by this invention -- like -- if the slanting electric field which consist of two directions are impressed -- liquid crystal molecule A tilt (tilt down) is carried out to a 2-way. Namely, pre tilt angle alpha 0 of a vertical substrate Since it means that that it is both 90 degrees does not have the direction of the direction of a substrate flat surface in the liquid crystal molecule of a vertical substrate front face, there is no constraint in the direction of a tilt. The degree of freedom of the direction of a tilt of the liquid crystal molecule in this case is in infinity.

[0039] Others are the cases of the molecular arrangement (generally it is called a bend array) in which the inclination from the perpendicular direction of a liquid crystal molecule has the direction of a pre tilt of the same direction with a vertical substrate using the liquid crystal constituent of a negative dielectric constant anisotropy. In this case, the direction which carries out a tilt down Two or more kinds arise. That is, a degree of freedom There are two or more.

[0040] However, even if it uses the liquid crystal constituent of a negative dielectric constant anisotropy,

when a liquid crystal molecule inclines a little from a perpendicular direction (90 degrees) and it makes a uniform tilt array with a vertical substrate, a degree of freedom It is set to 1 and is outside the object of this invention.

[0041] If the molecular arrangement of LCD of such this invention is shown notionally, it will become like drawing 12 . The twist direction of this liquid crystal molecule and a twist degree are controllable by the class of chiral liquid crystal agent mixed with liquid crystal, and the amount of mixing. As a concrete ingredient, it is octyl -2 to a left-handed-rotation chiral agent. - Oxy- -four [-(2-methylbutyl)- It can mention biphenyl (the Merck Limited, Inc. make) one, CB-15 / for example, /.] -(4'-n- HEKISHIROKISHI)- It is 4-cyano to benzole (Merck Japan make), S-811 [for example,], and a right-handed-rotation chiral agent. - 4'

[0042] Drawing 12 (a) to drawing 12 (f) is the surface direction of orientation and the surface pre tilt angle alpha 0 of a liquid crystal molecule of the vertical substrates 11 and 12. Are the same. And in the condition that there is no twist in a liquid crystal molecule, since the effect of the molecular arrangement on [in case electrode configurations differ, respectively] is shown, as for drawing 12 (a) thru/or drawing 12 (c), the condition, drawing 12 (d), or drawing 12 (f) at the time of no electrical-potential-difference impressing expresses the condition at the time of electrical-potential-difference impression. Here, drawing 12 (a) and drawing 12 (d) show the condition that the electrode configuration of a vertical substrate is equal and electric field are impressed only in the direction of liquid crystal thickness. location d0 of the molecule with which a liquid crystal molecule becomes a substrate and parallel it has at the middle point of the liquid crystal thickness d, and is shown in drawing 12 (d) -- as -- electrodes 13 and 14 -- power source v0 from -- even if it impresses an electrical potential difference, the location does not change. Drawing 12 (b) formed the electrode 14 of the bottom substrate 12 in the left half in drawing, and made the right half the non-electrode field, the electrode 13 of another side of the upper substrate 11 was formed in drawing Nakamigi one half, a left half is what was made into the non-electrode field, and the mutual electrodes 13 and 14 have met the non-electrode field.

[0043] Electrical potential difference v0 If it impresses, the electric field which have a horizontal electric-field component in a liquid crystal layer for a gap of both electrodes are added, and it is the arrow head ER of illustration upward slanting to the right. Since the line of electric force e with a component is generated, as shown in drawing 12 (e), Molecule M becomes steep molecular arrangement upward slanting to the right.

[0044] On the other hand, drawing 12 (c) formed the electrode 14 of the bottom substrate 12 in drawing Nakamigi one half, and made the left half the non-electrode field, the electrode 13 of another side of the upper substrate 11 was formed in the left half in drawing, a right half is what was made into the non-electrode field, and the mutual electrodes 13 and 14 have met the non-electrode field. It is an electrical potential difference v0 like drawing 12 (f). If it impresses, the electric field which have a horizontal electric-field component in a liquid crystal layer for a gap of both electrodes are added, and it is the arrow head EL of the left riser of illustration. Since the line of electric force e with a component is generated, the sense of the liquid crystal molecule M becomes the array of a steep left riser. That is, it depends for the array of the liquid crystal molecule at the time of electrical-potential-difference impression on formation of horizontal electric field.

[0045] Then, the upper electrode 13 is used as the electrode pattern which has arranged two or more stripe-like conductor section 13a at equal intervals through non-conductor section 13b like drawing 1 (a) which shows this example. As a pattern which has arranged two or more stripe-like conductor section 14a for the bottom electrode 14 at equal intervals through non-conductor section 14b similarly, when carrying out phase opposite of these electrodes It piles up so that the conductor sections 13a or 14a of one electrode may counter the non-conductor sections 14b or 13b of the electrode of another side and a gap may be formed between substrates. In this case, rubbing processing is carried out so that the direction of liquid crystal orientation of a vertical substrate may become in the same direction. Consequently, at the time of electrical-potential-difference impression, although liquid crystal holds a spray array condition tidily at the time of non-electrical-potential-difference impression, since the conductor section has shifted with the vertical electrode, the slanting electric field which have a horizontal electric-field component in inter-electrode occur, and the line of electric force e into which the inclination direction was changed by turns like illustration is formed. Since it rises and arranges along with line of electric force, a liquid crystal array becomes discontinuous on the boundary of upward-slant-to-the-right slanting electric field and left riser slanting electric field, and Wall Rhine DL generates the liquid crystal molecule M.

[0046] If a large number formation of the conductor section and the non-conductor section of an electrode is minutely carried out within 1 pixel, since the direction where a liquid crystal molecule rises will be divided

minutely, much Wall Rhine can be generated in 1 pixel, and light scattering can be made to cause in this part. a light-scattering field -- a core [section / boundary] -- width of face 5 thru/or 30 micrometers it is -- since -- if it divides so that it may become a value smaller than it so that a detailed area size may be made in agreement in the range of this value or, light can be scattered about on the whole 1-pixel surface. Specifically, it is 50 micrometers about the width of face of the largest part of the conductor section. It is 50 micrometers about the width of face of the largest part of the non-[the following and] conductor section. Considering as the following is desirable. moreover -- the condition of not impressing the electrical potential difference -- a liquid crystal molecule -- the whole surface -- since a continuous array is made, a light transmission condition can be acquired. Therefore, according to this invention, electric-field control which acquires a light-scattering condition at the time of a light transmission condition and electrical-potential-difference impression can be performed at the time of no electrical-potential-difference impressing.

[0047] Here, it is desirable for the pre tilt angle of a vertical substrate to be equal since the direction to which a liquid crystal molecule inclines is controlled by the direction of the electric field impressed, and this invention is the difference of the pre tilt angle of a vertical substrate practical. It is desirable to make it 0.5 degrees or less.

[0048] As for the molecular arrangement change in each field, equally to change of molecular arrangement, when it sees microscopically, in order that a speed of response may take the value according to this, it turns out that a speed of response is still quicker than TN-LCD of the conventional uniform twist array, STN-LCD, and the homogeneous array LCD, therefore LCD of this invention will also obtain a very quick speed of response.

[0049] Moreover, LCD of this invention is a light transmission condition and a light-scattering condition by slight liquid crystal molecular arrangement change. Since two conditions are acquired, a hysteresis is not produced in an electro-optics property.

[0050] Moreover, by the difference in the twist include angle (0 " is included) of liquid crystal, since the combination of the molecular arrangement condition of the boundary of the above-mentioned field also differs, various combination can become possible and what has a steep electro-optics property, a gently-sloping thing, etc. can be realized variously. However, twist angle When it was made larger than 270 degrees and switches to the condition of not impressing, from an electrical-potential-difference impression condition, memory of the molecular arrangement of an electrical-potential-difference impression condition may be carried out. Since this makes an electro-optics property produce a hysteresis as a result, it is not desirable. Therefore, twist angle of the liquid crystal of LCD of this invention ** [0 degree cannot be found] It is good to consider as 270 degrees.

[0051] Moreover, LCD of this invention is twisted and it is an angle. It created and intersected perpendicularly at 0 degree. If it combines so that the absorption shaft of one [each rubbing direction (it thinks at a cel flat surface and is the same direction in a vertical substrate) and] polarizing plate may become parallel between two polarizing plates, even when the source of the scattered light is used, it can become the display of a transparency mold. In this case, it becomes the optical mode using the birefringence effectiveness, and although the permeability mentioned above falls, in order to realize a light transmission condition according to the light-scattering condition of a liquid crystal layer, the effectiveness that there are few viewing-angle dependencies is acquired. Since a phenomenon which a display reverses does not arise when it indicates by gradation especially, the display property which was superior to conventional TN-LCD etc. as a display of a direct viewing type can be acquired.

[0052] Moreover, since LCD of this invention can realize the light-scattering condition of a liquid crystal layer by slight liquid crystal molecular arrangement change, applied voltage serves as a very small value. Therefore, the advantage that a low-battery drive is attained can also be acquired.

[0053] Drawing 15 (a) to drawing 14 (c) and drawing 15 (c) explain the electrode structure of LCD of some embodiments of this invention shown in claim 5 below, and molecular arrangement structure from drawing 13 (c) from drawing 13 (a), and drawing 14 (a). Drawing 13 (a), drawing 14 (a), and drawing 15 (a) are the perspective views showing the outline of electrode structure, and the sectional view in which drawing 13 (b), drawing 14 (b), and drawing 15 (b) show the outline of electrode structure, drawing 13 (c), drawing 14 (c), and drawing 15 (c) are the sectional views showing the outline of the liquid crystal molecular arrangement in the condition of having impressed electric field.

[0054] Moreover, drawing 16 is drawing having shown the cross-section structure of the component at the time of applying to the example which showed the structure of LCD of claim 8 to drawing 13 (c), drawing 14 (c), and drawing 15 (c).

[0055] It is each to each opposed face of the up-and-down substrates 11 and 12 which consist of glass etc. in

each drawing. The vertical stripe-like electrodes 13 and 14 are arranged for every 1-pixel unit. It is the line of electric force with which an arrow head F produces the direction of rubbing of the upper substrate 11, and an arrow head R when the direction of rubbing of the bottom substrate 12 is shown and a dotted line e impresses an electrical potential difference to the vertical electrodes 13 and 14 from a power source 21 (drawing 13 (a)), and M shows the array of the liquid crystal molecule at that time. DL shows generated Wall.

[0056] In drawing 13 (b) and drawing 15 (b), width of face of FE and the bottom electrode 14 is set to RE, and such inter-electrode clearance width of face is set to SS for the width of face of the upper electrode 13 when seeing in the direction of a substrate normal from the upper substrate 11 side. Furthermore, in drawing 14 (b), width of face of the part which RE(s) and these electrodes overlap in the width of face of the part to which FE and the bottom electrode 14 do not lap the width of face of the part to which the upper electrode 13 when seeing in the direction of a substrate normal from the upper substrate 11 side does not lap with the bottom electrode 14 with the upper electrode 13 is set to EE. Moreover, also in which drawing, the member which is not directly related to the description of this inventions, such as a gap agent between substrates (spacer), is omitted.

[0057] Furthermore, both drawing 15 (c) and drawing 1 (b) have shown the configuration when the molecular arrangement of liquid crystal considers as the so-called spray array from drawing 13 (a) of this invention. The configuration of drawing 1 R> 1 has the structure where the current carrying part and the non-current carrying part countered mutually between vertical substrates like illustration, and said current carrying part and non-current carrying part were arranged by turns in both substrates (such an electrode configuration is defined as "nesting".).

[0058] So that drawing 15 (c) may be understood from drawing 13 (a) as compared with drawing 1 (b) the electrode structure of this invention The configuration shown in drawing 13 (b) has electrode structure which prepared the place (part of SS) which also serves as a vertical substrate with the non-current carrying part between the parts (FE and part of RE) which the current carrying part and the non-current carrying part have countered mutually between vertical substrates to the electrode structure of "nesting" shown in drawing 1 (b). Therefore, as shown in drawing 13 (b) in this way, the cross-section configuration of the electrode structure of a vertical substrate defines such an electrode configuration as "nesting with a clearance" for convenience from having arranged in order, such as said FE, SS, RE, SS, FE, SS, RE, SS, FE, SS, and --.

[0059] Moreover, what is shown in drawing 14 (b) has electrode structure which prepared the overlapping place (part of EE) which also serves as a vertical substrate with the current carrying part between the parts (FE and part of RE) which the current carrying part and the non-current carrying part have countered mutually between vertical substrates. Therefore, as shown in drawing 14 (b) in this way, the cross-section configuration of the electrode structure of a vertical substrate defines such an electrode configuration as "duplication nesting" for convenience from having arranged in order, such as said FE, EE, RE, EE, FE, EE, RE, EE, FE, EE, and --.

[0060] Moreover, it is the change form of the electrode structure of drawing 13 (b) which is shown in drawing 15 (b), and it is electrode structure when the electrode configuration in the direction of a component flat surface is making the so-called stripe-like configuration. That is, the electrode structure shown in drawing 15 (b) draws electrode structure when the configurations of a current carrying part and a non-current carrying part are making and carrying out the parallel array of the straight-line configuration. Although the same configuration is considered also to duplication nesting of drawing 14 , illustration is omitted here. It is the electrode structure of such "nesting with a clearance", and "duplication nesting", and electrode structure when the electrode configuration in the direction of a component flat surface is making the so-called stripe-like configuration is defined as "stripe nesting with a clearance", and "duplication stripe nesting" for convenience.

[0061] Conversely, if it says, LCD proposed in this invention as shown in drawing 14 (a) has the description which liquid crystal molecular arrangement mentioned above, and if it is the electrode structure where many parts which change tilt bearing of a molecule remarkably in this are prepared, it is shown that the superficial configuration of electrode structure does not need to adhere to an orderly stripe configuration like drawing 15 (a). Nevertheless, it is because it found out that having set the electrode configuration of "stripe nesting with a clearance" like drawing 15 (a) and "duplication stripe nesting" to one of the descriptions of this invention had the description with which such an electrode configuration differed from drawing 14 (a).

[0062] Now, each features of an electrode configuration with these four features and its operation are explained. As compared with the part and "nesting" which have the non-current carrying part which shows "nesting with a clearance" shown in drawing 13 R> 3 (b) and drawing 15 (b), and "stripe nesting with a

clearance" by SS, slanting field strength becomes weak. While this raises driver voltage a little practical, it makes an electro-optics property a gently-sloping curve. Therefore, a drive becomes easy when giving a fine gradation indication. Moreover, a margin can be prepared in the alignment between the part which has the non-current carrying part shown by SS, and the vertical substrate of an electrode (doubling), and productivity improves remarkably. Moreover, "duplication nesting" as shown in drawing 14 (b), and "duplication stripe nesting" can acquire slanting electric field with low applied voltage as compared with "nesting with a clearance", "stripe nesting with a clearance", and "nesting." Therefore, driver voltage can be made low practical. However, since the electric-field component which starts in the direction of a normal arises into the part of EE, light-scattering reinforcement becomes low a little. however, "nesting with a clearance" and "stripe nesting with a clearance" -- a margin can be prepared in the alignment between the part which has similarly the current carrying part shown by EE, and the vertical substrate of an electrode (doubling), and productivity improves remarkably.

[0063] Moreover, as compared with "nesting with a clearance", and "duplication nesting", "stripe nesting with a clearance" and "duplication stripe nesting" serve as a notched configuration as the appearance configuration of Wall (drawing 13 (c), drawing 14 (c), orientation break point shown by DL of drawing 15 (c)) shows to drawing 17 . This configuration will raise light-scattering reinforcement as compared with a straight-line configuration. We are checking by various experiments that such a notched configuration becomes more notched, so that an electrode pattern is an orderly stripe configuration. From this, it can be said that the electrode structure of these "stripe nesting with a clearance" and "duplication stripe nesting" is electrode structure with the features of obtaining light-scattering reinforcement strong as a result.

[0064] As explained above, the electrode configuration of these versatility is the means which can solve the conventional trouble of having had and mentioned the features above, respectively. Although the molecular arrangement of liquid crystal was explained and came by spray-like molecular arrangement which does not have a twist by the explanation so far, as mentioned above, the direction of a tilt of a liquid crystal molecule If it is molecular arrangement with two or more degrees of freedom, it cannot be overemphasized that the same effectiveness is acquired.

[0065] Now, since it is constituted so that slanting electric field may conflict for every detailed field when Wall which was mentioned above in the various electrode configurations of these this inventions and molecular arrangement is generated, even if it continues impressing an electrical potential difference, a liquid crystal molecule cannot maintain easily molecular arrangement in the condition that Wall occurred. It is because a thing called liquid crystal molecular arrangement is difficult to change an array configuration not much minutely. getting it blocked -- the force of maintaining such a difficult molecular arrangement gestalt will be insufficient only in external force, such as electric field and a field. In order to solve such a problem, a particle with liquid crystal thickness lay length shorter than the liquid crystal thickness d is made to mix in both the substrates gap. Or we found out solving, if the projection with the height of the direction of liquid crystal thickness lower than an electrode spacing D (this spacing is substantially equal to the liquid crystal thickness d) is prepared at least in one side of said both substrates.

[0066] Drawing 16 shows the outline of this configuration. It consists of structure which added the particle 22 smaller than the liquid crystal thickness d so that it may illustrate. thus, when a particle and a projection were prepared into the liquid crystal layer 20 and the appearance location in said Wall had this particle and a projection, it mentioned above by these existence -- an array configuration is changed minutely -- making -- a molecular arrangement condition -- getting it blocked -- it found out maintaining the molecular arrangement condition of having made much Wall appearing. Since such a particle and a projection have the function to maintain much Wall, the "Wall base material" is called. it is obtained by what is also made to mix the particle of magnitude equal to liquid crystal thickness besides the approach shown in this invention as a means to obtain such a function, in said liquid crystal layer beyond the need (getting it blocked -- mixing of a substrate gap agent). However, in order to maintain much Wall in this case, it will be necessary to make many substrate gap agents mix, and a bad influence is done when acquiring a light transmission condition. When it states concretely, it is the effect of light scattering by the substrate gap agent, and light scattering by the liquid crystal molecular orientation of a substrate gap agent front face. In this invention, in order to reduce these effects, we decided to use the particle characterized by being smaller than the liquid crystal thickness d as said Wall base material, and a projection. Thus, the artificer etc. is checking by experiment that light scattering resulting from these can be made into satisfactory level by using a particle smaller than the liquid crystal thickness d and a projection.

[0067] In addition, the level difference (level difference produced with the thickness of a wiring electrode or a semi-conductor layer) itself inevitably prepared in TFT and the MIM substrate other than a particle and a

projection which were mentioned above as what obtains the function of this Wall base material is checking obtaining the same function near [said] the level difference.
[0068] Furthermore, as the configuration is shown in drawing 18 , drawing 19 , and drawing 20 , the permeability and contrast at the time of no electrical-potential-difference impressing can be raised by forming the bottom translucency insulator layer 18 on the upper electrode 13 or the upper electrode 13, and a projection on the upper translucency insulator layer 17, a bottom electrode or a bottom electrode, and a projection. In addition, the orientation film 15 and 16 is formed on these translucency insulator layer. However, a bottom translucency insulator layer is not prepared in drawing 20 . Electrodes 13 and 14 are made of ITO, and the refractive index is abbreviation. It is the abbreviation of a substrate, the orientation film, and a liquid crystal layer at 1.9. It is higher than 1.5. Then, the refractive index of a translucency insulator layer is selected to the refractive index of an electrode material, an EQC, or the value near it. It is the refractive index of an electrode material practical. 0.9-1.1 Doubling is desirable. Hereafter, the reason is explained. As shown in drawing 21 , the difference of the refractive index of ITO, other ingredients 11 and 12, i.e., substrates, and the liquid crystal layer 20 is large. On the other hand, since the pixel electrode is divided into the detailed field of the ITO conductor sections 13a and 14a and the non-conductor sections 13b and 14b, an optical path will lap from the refractive-index difference of the conductor section in a pixel electrode, and the non-conductor section, and interference of light will take place. Therefore, if interference of such a light can be lost, the permeability and contrast at the time of no electrical-potential-difference impressing can be raised.
[0069] Interference of light has the large difference of the refractive index of a pixel electrode material and other ingredients, and since it is divided into the field where the conductor section and the non-conductor section are detailed within the pixel electrode, when the degree to which incident light is refracted in the conductor section and the non-conductor section is different, it takes place. For this reason, what is necessary is just to make incident light similarly refracted in the conductor section and the non-conductor section within a pixel electrode, in order to prevent a pixel inter-electrode optical interference. Therefore, if a translucency insulator layer with the almost same refractive index as a pixel electrode material is applied on a pixel electrode, since the light by which incidence was carried out to the non-conductor section in a pixel electrode is also equal to the light by which incidence was carried out to the conductor section and light is refracted, interference of light can be controlled. A pixel electrode is constituted from ITO by a translucency conductor and the practical use target. For this reason, what is necessary is just to use a translucency insulator layer with the almost same refractive index as ITO. Namely, refractive index of an electrode material 0.9-1.1 If it is the twice as many range as this, the decline in the permeability by optical interference will not be produced mostly. Moreover, the thickness of a translucency insulator layer is the thickness of translucency electrode layers, such as ITO. Sufficient effectiveness will be acquired if it is 1/2 or more.
[0070]
[Example] Hereafter, the example of LCD of this invention is concretely explained with reference to a drawing.
The perspective view in which example 1 drawing 1 (a) shows the pattern of the vertical electrode of this example, and drawing 1 (b) are the abbreviation sectional views of the liquid crystal cell which carried out phase opposite of the electrode. The transparence common electrode 13 made in ITO all over one field of the upper substrate 11 made with glass is formed, and the laminating of the upper orientation film (AL-3046, Japan Synthetic Rubber make) 15 of polyimide is carried out to the front face. The pixel electrode 14 made into the whole surface of the bottom electrode 12 made with the glass of another side in ITO is formed, and the laminating of the bottom orientation film 16 of polyimide (AL-3046, Japan Synthetic Rubber make) is carried out to the front face. magnitude of 1 pixel 300 micrometers x 300micrometer it is -- the pixel electrode 14 is arranged in the shape of a mosaic per pixel. Pre tilt angle of the vertical orientation film 15 and 16 It is 3 degrees.
[0071] upper electrode 13 Every pixel width of face of 20 micrometers two or more slits, i.e., non-current-carrying-part 13b, -- having -- width of face of 20 micrometers 13a40 micrometers of current carrying parts it is the pattern arranged in the shape of a stripe in the pitch -- 1 pixel 300 micrometers Inside of width of face Six current-carrying-parts 13a is formed. the bottom electrode 14 which faces -- the same -- 20 micrometers Current-carrying-part 14a of width of face, and 20 micrometers it has the pattern which has arranged non-current-carrying-part 14b of width of face at equal intervals -- 300 micrometer Inside of width of face Six current-carrying-parts 14a is formed.
[0072] The current carrying part of these electrodes is 20 micrometers to mutual in the condition of having

made the vertical substrate facing. It has shifted and the current carrying parts 13a or 14a of one electrode meet the non-current carrying parts 14b or 13b of the electrode of another side. The bottom electrode 14 has the TFT switching element 19, and is connected to the gate line 23 and a signal line 24.

[0073] The directions F and R of orientation of the vertical orientation film 15 and 16 are set up so that it may intersect perpendicularly with the current carrying part of an electrode like illustration, and so that it may become the same direction. Moreover, it is 10 micrometers about the gap of a vertical substrate. It carries out and a liquid crystal cell is formed. A dielectric constant anisotropy fills up this substrate gap with a forward pneumatic liquid crystal (ZLI-3926, Merck Japan make), and it considers as the liquid crystal layer 20. This liquid crystal has a rate of a birefringence as large as 0.2030 (**n). The light-scattering nature of LCD can be raised that this rate of a birefringence (**n) is large, and by choosing the thick liquid crystal layer of 10 micrometers and thickness.

[0074] Thus, the electrical potential difference was impressed to LCD of obtained this invention from the power source 21 through TFT19, and the electro-optics property (permeability-applied-voltage curve) was measured. by electrical-potential-difference impression, the electric field which have a horizontal electric-field component in inter-electrode occur -- since the direction of a horizontal electric-field component changes in the minute range which is 1 pixel, the liquid crystal molecule M of the liquid crystal layer 20 changes an array according to electric field. Therefore, much Wall Rhine DL occurs on the boundary of a liquid crystal array, and a light-scattering condition is made.

[0075] In order to ask for a permeability-applied-voltage curve, it is helium-Ne to LCD. Incidence of the laser light was carried out and permeability was measured. A measurement result is shown in drawing 23 . In addition, the diameter of a spot of light is 2mm. The photodiode which is in a place with a distance of 20cm from LCD detected a transmitted laser light. Moreover, applied voltage It is from 0V. It is made to increase to 5V and is after that. It is from 5V. It was made to decrease to 0V. In the condition (0V impression) of not impressing the electrical potential difference, the bright permeability property was indicated to be about 80% of permeability. Moreover, applied voltage In 2.8V, the 0.4% of the minimum permeability and a good light-scattering condition were acquired. Moreover, there was no hysteresis in an electro-optics property so that clearly from drawing 23 . Moreover, applied voltage It reaches 2.8V. In 0V, it started, when the speed of response was measured, and 7msec(s), falling 25msec, and a very quick value were acquired.

[0076] This example is shown in example 2 drawing 22 (a) and drawing 22 (b). it is shown in drawing 2222 (a) -- as -- pattern with current-carrying-part 13c of the upper electrode 13, current-carrying-part 14a of 13d of non-current carrying parts, and the bottom electrode 14, and non-current-carrying-part 14b It lies at right angles within 1 pixel. It is the same configuration as an example 1 except the pattern of this current carrying part. The parts of an example 1 and a jack per line show the same part here. However, the liquid crystal layer used for liquid crystal (ZLI-3926, Merck Japan make) forward in a dielectric constant anisotropy the liquid crystal constituent which added the chiral agent (S-811, Merck Japan make) of a left twist. Moreover, as shown in drawing 22 (b), they are the directions F and R of orientation of a vertical substrate. 180 degrees is shifted and it is a liquid crystal molecule. It considered as the spray array of 180-degree twist.

[0077] In this structure, the field with which the current carrying parts 13c and 14a of the vertical electrodes 13 and 14 lap, and the field where the current carrying parts 13c or 14a of one electrode meet the non-current carrying parts 14b or 13d of other electrodes are generated. However, it acts so that the horizontal electric-field component produced at the time of electrical-potential-difference impression may occur intricately and may disturb liquid crystal molecular arrangement. For this reason, light scattering sufficient in a 1-pixel minute field can be acquired by very quick responsibility.

[0078] Example 3 drawing 24 (a) is the abbreviation sectional view of the liquid crystal cell which carried out phase opposite of the electrode in this example, and drawing 24 (b). About the upper electrode pattern of a 1-pixel field, it is drawing 24 (c). The bottom electrode pattern of a 1-pixel field is shown. As shown in drawing 24 (a) and drawing 24 (b), the glass substrate in which the common electrode 13 of ITO which becomes each pixel from non-current-carrying-part 13b of a crookedness stripe pattern and current-carrying-part 13a as an upper substrate 11 was formed is used. In addition, the Black matrix which consists of chromium throughout a non-picture element part is formed. As shown in drawing 24 (a) and drawing 24 (c), the glass substrate in which the switching element which consists of a common electrode 14 of ITO which becomes each pixel from non-current-carrying-part 14b of a crookedness stripe pattern and current-carrying-part 14a as a bottom substrate 12, and TFT was formed is used. The upper electrode pattern shown in drawing 24 (b) is the width of face of the current carrying part of the direction which intersects perpendicularly in the stripe extension direction. 5 micrometers Crest of a current carrying part - It is 10

micrometers about the width of face of 10 micrometers and a non-current carrying part in the width of face of a gap. It carried out. Moreover, the bottom electrode pattern shown in drawing 24 (c) is the width of face of a current carrying part. 5 micrometers It is 10 micrometers about the width of face of a non-current carrying part. It carried out.

[0079] The orientation film 15 and 16 (trade name SE-7120, Nissan Chemical Industries make) (measured value of a pre tilt angle 6 degrees) is formed on the electrode pattern of this substrate, and rubbing processing is performed in the directions F and R which show that front face in drawing. subsequently, liquid crystal thickness becomes as a substrate gap agent at a bottom substrate side -- as -- particle 7.5 micrometers (the trade name micro pearl SP --) It is a distributed consistency about the product made from the Sekisui fine chemical (particle size 7.5 micrometers). 100 piece/mm2 After sprinkling by the dry type sprinkling method so that it may become, Among these substrates, the dielectric constant anisotropy pinched the forward liquid crystal constituent (trade name ZLI-3926, Merck Japan make) (**n=0.2030), and LCD of this example which consists of an electrode configuration of "nesting with a clearance" mentioned above was obtained. Here, liquid crystal thickness was thickened and the dielectric constant anisotropy of a liquid crystal constituent was enlarged for raising the light-scattering nature in a light-scattering condition.

[0080] Thus, it measured by the approach of impressing an electrical potential difference to obtained LCD through TFT, and showing an electro-optics property (permeability-applied-voltage curve) in an example 1. A measurement result is shown in drawing 2727 . In the condition (0V impression) of not impressing the electrical potential difference, the bright permeability property was indicated to be about 80% of permeability. Moreover, applied voltage At 3.1V-3.9V, it is the minimum permeability. 0.4% and a good light-scattering condition were acquired. Moreover, there was no hysteresis in an electro-optics property so that clearly from drawing. Moreover, applied voltage It reaches 3.1V. In 0V, it started, when the speed of response was measured, and 6msec(s), falling 18msec, and a very quick value were acquired.

[0081] Next, the molecular arrangement observation by the polarization microscope and the light-scattering condition measurement by transmissometry investigated the maintenance condition of Wall of having impressed and mentioned the electrical potential difference above through TFT of a bottom substrate. It sets to this example and is applied voltage. When 3.1V continue being impressed, even if 1 hour passed, maintaining the early Wall array was checked.

[0082] Perpendicular orientation processing of the substrate was carried out at the orientation film 15 and 16 using the processing agent for perpendicular orientation processing (trade name ODS-E (Octadecyltrietoxysilane alcoholic solution), Chisso make) using the same substrates 11 and 12 as example 4 example 3. Perpendicular orientation processing is performed by immersing each substrate in the alcoholic above-mentioned solution here. The vertical substrate of the obtained pre tilt angle was 90 degrees. LCD of this example was obtained with the same conditions as an example 3, and an ingredient except using the pneumatic liquid crystal ingredient (trade name ZLI-4850 (**n=0.208), Merck Japan make) in which a negative dielectric constant anisotropy is shown as a liquid crystal constituent. Like the example 3, when many properties were measured, as shown in drawing 27 , the result almost equivalent to an example 3 of having excelled was obtained.

An upper substrate electrode pattern is shown in example 5 drawing 25 (a), and a bottom electrode pattern Fig. is shown in drawing 25 (b), respectively. The glass substrate which put the common electrode 13 which formed the Black matrix which consists of chromium throughout a non-picture element part as an upper substrate, and formed narrow non-current-carrying-part 13b for every pixel from current-carrying-part 13a of a wave stripe and this by ITO patterning is used. The glass substrate with a switching element which consists of a bottom electrode 14 with current-carrying-part 14a which has narrow non-current-carrying-part 14b rather than non-current-carrying-part 13b of an upper substrate, and TFT (not shown) as a bottom substrate was used. Field 14c which surrounds a bottom substrate here is wiring and a TFT formation field. LCD of this invention which consists of an electrode configuration of "duplication nesting" mentioned above using the same conditions as an example 3 and an ingredient was produced using these substrates. The electro-optics property (permeability-applied-voltage curve) of LCD in this example was measured on the same approach as an example 3, and conditions. The result is shown in drawing 27 .

[0083] In the condition (0V impression) of not impressing the electrical potential difference, the bright permeability property was indicated to be about 80% of permeability. Moreover, applied voltage It is the minimum permeability at a low battery to 2.5V-3.3V and three or more examples. 0.5% and a good light-scattering condition were acquired. Moreover, there was no hysteresis in an electro-optics property so that clearly from drawing. Moreover, applied voltage It reaches 2.5V. In 0V, it started, when the speed of response was measured, and 5msec(s), falling 12msec, and a very quick value were acquired.

[0084] Next, the molecular arrangement observation by the polarization microscope and the light-scattering condition measurement by transmissometry investigated the maintenance condition of Wall of having impressed and mentioned the electrical potential difference above through TFT in LCD of this example. It sets to this example and is applied voltage. When 2.5V continue being impressed, even if 1 hour passed, maintaining the early Wall array was checked.
[0085] An upper substrate electrode pattern is shown in example 6 drawing 26 (a), and a bottom electrode pattern Fig. is shown in drawing 26 (b), respectively. The glass substrate which formed the common electrode 13 which formed the Black matrix which consists of chromium throughout a non-picture element part as an upper substrate, and formed current-carrying-part 13a of a straight-line stripe and non-current-carrying-part 13b for every pixel by patterning of ITO is used. The glass substrate with a switching element which serves as the bottom electrode 14 which consists of current-carrying-part 14a of a straight-line stripe and non-current-carrying-part 14b for every pixel as a bottom substrate from TFT is used. width of face of the current carrying part of a vertical electrode 5 micrometers the width of face of a non-current carrying part -- 10 micrometers it is .
[0086] LCD of this example which consists of an electrode configuration of "stripe nesting with a clearance" mentioned above using the same conditions as an example 3 and an ingredient was produced using these substrates. The electro-optics property (permeability-applied-voltage curve) of LCD in this example was measured on the same approach as an example 3, and conditions. The result is shown in drawing 2727 .
[0087] In the condition (0V impression) of not impressing the electrical potential difference, the bright permeability property was indicated to be about 80% of permeability. Moreover, applied voltage It is the minimum permeability at 3.2V-3.9V. 0.2% and a three or more-example good light-scattering condition were acquired. Moreover, there was no hysteresis in an electro-optics property so that clearly from drawing. Moreover, applied voltage It reaches 3.2V. In 0V, it started, when the speed of response was measured, and 6msec(s), falling 18msec, and a very quick value were acquired. Next, the molecular arrangement observation by the polarization microscope and the light-scattering condition measurement by transmissometry investigated the maintenance condition of Wall of having impressed and mentioned the electrical potential difference above through TFT in LCD of this example. It sets to this example and is applied voltage. The case where 3.2V continue being impressed, even if 1 hour passed, maintaining the early Wall array was checked.
It is a particle (a trade name micro pearl, product made from the Sekisui fine chemical) (particle size 5.0 micrometers) 1000 distributed consistencies/mm as a Wall base material mentioned above in the upper substrate side after performing orientation processing with the same approach and an ingredient using the same vertical substrate as example 7 example 3 2 Sprinkling by the dry type sprinkling method so that it might become, subsequent processes produced LCD of this invention with the same approach as an example 1, and the ingredient. When many properties were measured on the same approach as an example 3, and conditions, as shown in drawing 27 R> 7, the result almost equivalent to an example 3 of having excelled was obtained.
[0088] Moreover, the molecular arrangement observation by the polarization microscope and the light-scattering condition measurement by transmissometry investigated the maintenance condition of Wall of having impressed and mentioned the electrical potential difference above through TFT in LCD as well as an example 3. It sets to this example and is applied voltage. It is 10 the case where 3.1V continue being impressed. Even if it carried out time amount progress, maintaining the early Wall array was checked.
[0089] Example 8 drawing 28 (a) is the abbreviation sectional view of the liquid crystal cell which carried out phase opposite of the electrode, and drawing 28 (b). About the upper electrode pattern of a 1-pixel field, it is drawing 2828 (c). The bottom electrode pattern of a 1-pixel field is shown. The electrode pattern of a vertical substrate is the same as that of an example 3. A refractive index as translucency insulator layers 17 and 18 on the pixel electrodes 13 and 14 of vertical both substrates The overcoat of the translucency insulating material (206 trade name RTZ- a catalyst formation product made from industry) of 1.9 is carried out. 1.0 micrometers It considered as the translucency layer of thickness and the substrate of a configuration of being shown in drawing 28 (a) was obtained. LCD was obtained on the same approach as an example 3, and conditions using this substrate. It measured by the approach of showing the electro-optics property (permeability-applied-voltage curve) of obtained LCD in an example 1. A measurement result is shown in drawing 29 .
[0090] In the condition (0V impression) of not impressing the electrical potential difference, the bright permeability property was indicated to be about 85% of permeability. Moreover, applied voltage At 3.3V, it is the minimum permeability. 0.4% and a good light-scattering condition were acquired. Moreover, there

was no hysteresis in an electro-optics property so that clearly from drawing. Moreover, applied voltage It reaches 3.1V. In 0V, it started, when the speed of response was measured, and 6msec(s), falling 18msec, and a very quick value were acquired. Next, the molecular arrangement observation by the polarization microscope and the light-scattering condition measurement by transmissometry investigated the maintenance condition of Wall of having impressed and mentioned the electrical potential difference above through TFT of a bottom substrate. It sets to this example and is applied voltage. When 3.1V continue being impressed, even if 1 hour passed, maintaining the early Wall array was checked.

[0091] A refractive index on the pixel electrode using the vertical substrate which has the electrode pattern shown in example 9 example 4 1.90 The overcoat of the translucency insulating material (606 trade name RTZ- a catalyst formation product made from industry) is carried out. 1.0 micrometers The substrate which has the translucency layer of thickness was obtained. LCD was obtained on the same approach as an example 4, and conditions using this substrate. It measured by the approach of showing the electro-optics property (permeability-applied-voltage curve) of obtained LCD in an example 1. A measurement result is shown in drawing 29 R> 9.

[0092] As shown in drawing 29 , the result almost equivalent to an example 8 of having excelled was obtained. Moreover, the speed of response and the maintenance condition of Wall were also mostly excellent in the EQC with the example 8. Furthermore, the optical interference by the electrode at the time of no electrical-potential-difference impressing did not arise to incident light, but the permeability at the time of no electrical-potential-difference impressing improved, and the improvement effectiveness of contrast was seen.

[0093] A refractive index on the pixel electrode using the vertical substrate which has the electrode pattern shown in example 10 example 5 1.90 The overcoat of the translucency insulating material (606 trade name RTZ- a catalyst formation product made from industry) is carried out. 1.0 micrometers The substrate which has the translucency layer of thickness was obtained. LCD was obtained on the same approach as an example 5, and conditions using this substrate. It measured by the approach of showing the electro-optics property (permeability-applied-voltage curve) of obtained LCD in an example 1. A measurement result is shown in drawing 29 R> 9.

[0094] As shown in drawing 29 , the result almost equivalent to an example 8 of having excelled was obtained. Moreover, the speed of response and the maintenance condition of Wall were also mostly excellent in the EQC with the example 8. Furthermore, the optical interference by the electrode at the time of no electrical-potential-difference impressing did not arise to incident light, but the permeability at the time of no electrical-potential-difference impressing improved, and the improvement effectiveness of contrast was seen.

[0095] LCD was obtained on the same approach as an example 8, and conditions except using the vertical substrate which has the electrode pattern shown in example 11 example 6. It measured by the approach of showing the electro-optics property (permeability-applied-voltage curve) of obtained LCD in an example 1. A measurement result is shown in drawing 29 .

[0096] As shown in drawing 29 , the result almost equivalent to an example 8 of having excelled was obtained. Moreover, the speed of response and the maintenance condition of Wall were also mostly excellent in the EQC with the example 8. Furthermore, the optical interference by the electrode at the time of no electrical-potential-difference impressing did not arise to incident light, but the permeability at the time of no electrical-potential-difference impressing improved, and the improvement effectiveness of contrast was seen.

[0097] LCD was obtained on the same approach as an example 8, and conditions except using the vertical substrate which has the electrode pattern shown in example 12 example 7. It measured by the approach of showing the electro-optics property (permeability-applied-voltage curve) of obtained LCD in an example 1. A measurement result is shown in drawing 29 . As shown in drawing 29 , the result almost equivalent to an example 8 of having excelled was obtained. Moreover, the speed of response and the maintenance condition of Wall were also mostly excellent in the EQC with the example 8. Furthermore, the optical interference by the electrode at the time of no electrical-potential-difference impressing did not arise to incident light, but the permeability at the time of no electrical-potential-difference impressing improved, and the improvement effectiveness of contrast was seen.

[0098] As shown in example 13 drawing 30 , the substrate which formed the upper electrode 13 by the electrode pattern which shows the bottom electrode 14 to an example 6 on the bottom substrate 12 is used on the upper substrate 11, and it is particle size on the field by the side of the electrode of both substrates. 1.5 micrometers It is a distributed consistency about a particle 22 (the trade name micro pearl SP, product

made from the Sekisui fine chemical). 1000 An individual / mm2 It sprinkled so that it might become. On these electrodes and a particle, the overcoat of the translucency insulator layers (206 trade name RTZ- a catalyst formation product made from industry) 17 and 18 was carried out, and both the substrates front face was finished in the uneven side. LCD was obtained on the same approach as an example 8, and conditions except using the bottom substrate of besides. The outstanding electro-optics property with obtained LCD almost equivalent to an example 8, the speed of response, and the maintenance condition of Wall were acquired. moreover, a translucency insulator layer -- the conductor of an electrode -- the break of the section was solved optically and has prevented an optical interference.

[0099] Example 14 drawing 31 (a) is the abbreviation sectional view of the liquid crystal cell which carried out phase opposite of the electrode of this example, and drawing 31 (b). About the upper electrode pattern of a 1-pixel field, it is drawing 31 (c). Drawing 3131 (d) shows the liquid crystal molecular arrangement at the time of electrical-potential-difference impression for the bottom electrode pattern of a 1-pixel field. The upper electrode 13 used the ITO solid electrode, as shown in drawing 31 (b). The Black matrix which shades a non-picture element part is not established. the bottom electrode 14 is shown in drawing 31 (c) -- as -- Magnitude of 1 pixel 30 mum x 40 mum it is -- ITO of the conductor section 4.5 micrometers width of face -- it is -- the non-conductor section 7 micrometers The spray pattern which is width of face is formed for every pixel. The TFT switching element 19 is formed for every pixel. 1280x1024 The bottom substrate which has the number of pixels is obtained.

[0100] The orientation film 15 and 16 (trade name SE-7120, Nissan Chemical Industries make) (measured value of a pre tilt angle 6 degrees) is formed on the electrode pattern of this substrate, and rubbing processing is performed in the directions F and R which show that front face in drawing. subsequently, liquid crystal thickness becomes as a substrate gap agent at a bottom substrate side -- as -- particle 6.0 micrometers (the trade name micro pearl SP --) It is a distributed consistency about the product made from the Sekisui fine chemical (particle size 6.0 micrometers). 100 piece/mm2 After sprinkling by the dry type sprinkling method so that it may become, Among these substrates, the dielectric constant anisotropy pinched the forward liquid crystal constituent (trade name ZLI-4792, Merck Japan make) (**n=0.094), and LCD of this example was obtained.

[0101] The description of the cel configuration of this example is explained below. It is shown by three descriptions. It is that liquid crystal molecular arrangement has arranged to the direction of an electrode stripe, and parallel in the condition of 1st not impressing the electrical potential difference. That is, the direction of slanting electric field and liquid crystal molecular arrangement at the time of impressing an electrical potential difference lie at right angles. Therefore, if an electrical potential difference is impressed, slanting electric field will be formed in bearing which intersected perpendicularly with liquid crystal molecular arrangement, and the tilt of the liquid crystal molecule will be carried out, twisting in this direction. Consequently, the liquid crystal molecular arrangement in the condition of having impressed the electrical potential difference is seen from a cross section, is seen at drawing 31 (a) and a flat surface, and becomes like drawing 31 D. A refractive index [as opposed to the direction of an electrode stripe and the polarization component of the rectangular direction by such liquid crystal molecular arrangement] is the extraordinary index ne of a liquid crystal molecule. Tsunemitsu refractive index no It arranges by turns regularly in the rectangular direction of the direction of an electrode stripe. Therefore, a diffraction grating is formed in a liquid crystal layer, and parallel light can be scattered.

[0102] It is the electrode spacing D of both the substrates by which opposite arrangement was carried out in order to acquire slanting electric field effectively to the 2nd D>=S/2 It is trying to fill relation. S is the width of face of the narrowest part of the non-conductor section in the polar zone here. this example -- setting -- width of face S between the patterns of a stripe electrode pattern (drawing 31 (c)) 7 micrometers it is -- electrode spacing D of both the substrates by which opposite arrangement was carried out 6 micrometers it is -- since -- above-mentioned relational expression is satisfied.

[0103] To the 3rd, it is **nd of a liquid crystal layer. It is having set it as 564nm. This value is smaller than an above-mentioned example. This is for the light-scattering effectiveness of a diffraction grating to be dependent on **nd. The light-scattering effectiveness of a diffraction grating is GALE, M.et al.:1979, J.appl.Photogr.Engng, 4, and 41. It is shown by the degree type when it depends.

T=cos2 (pi**nd/lambda)

T is scattered-about luminous intensity (reinforcement to incident light) here, and lambda is incident light wavelength. It depends for the light-scattering effectiveness of a diffraction grating on **nd from this formula. This **nd changes with applied voltage with the configuration of the liquid crystal cell of this example. The change width of face It is to the value (564nm) after **nd of the liquid crystal layer set up

from 0. Moreover, the light-scattering effectiveness of a diffraction grating has extremal value from a top type to **nd. Therefore, if the value of set-up **nd is more remarkably [than the extremal value of an upper type] large, extremal value will arise in the electro-optics property of a liquid crystal cell. This makes difficult the gradation expression which used the analog signal. For this reason, this is taken into consideration in this example, and it is **nd of a liquid crystal layer. It was set as 564nm. Thus, in addition to the dioptric lens effectiveness (the Wall array mentioned above: effectiveness of making the light which carried out incidence when a liquid crystal molecule changed an inclination in the direction of liquid crystal thickness continuously and a refractive index changed continuously refracted) which liquid crystal molecular arrangement forms like other examples, this example is taken as the structure where the diffraction-grating effectiveness is acquired clearly.

[0104] Thus, it measured by the approach of impressing an electrical potential difference to obtained LCD through TFT, and showing an electro-optics property (permeability-applied-voltage curve) in an example 1. A measurement result is shown in drawing 3232 . In the condition (0V impression) of not impressing the electrical potential difference, the bright permeability property was indicated to be about 80% of permeability. Moreover, applied voltage It is the minimum permeability more than in 3.2V. 0.2% and a good light-scattering condition were acquired. Moreover, there was no hysteresis in an electro-optics property so that clearly from drawing. Moreover, applied voltage It reaches 3.2V. In 0V, it started, when the speed of response was measured, and 7msec(s), falling 23msec, and a very quick value were acquired.

[0105] As example 15 orientation film, LCD was obtained by the same approach as an example 14 except using the liquid crystal constituent (trade name ZLI-4318, Merck Japan make) (**n=0.1243) which has a negative dielectric constant anisotropy as the orientation film 15 and 16 (trade name JALS-204-R14, Japan Synthetic Rubber Make) in which perpendicular orientation is shown, and a liquid crystal constituent.

[0106] The liquid crystal molecular arrangement seen superficially at the time of no electrical-potential-difference impressing [of LCD of this example] and electrical-potential-difference impression is shown in drawing 33 (a) and drawing 33 (b), respectively. In the state of no electrical-potential-difference impressing (drawing 33 (a)), the liquid crystal molecule is arranged uniformly (perpendicular orientation). On the other hand, in the state of electrical-potential-difference impression (drawing 33 (b)), in the place where ITO has countered with the vertical substrate, a tilt down is carried out in the rubbing bearing, and in the field which does not have ITO of a TFT substrate conversely, since slanting electric field occur in the direction of an electrode stripe, and the direction which intersected perpendicularly, a tilt down is carried out in the direction. Therefore, a refractive index [on the condition which LCD of this example indicated to the example 14 illustrated of having impressed the electrical potential difference like LCD, and as opposed to the direction of an electrode stripe and its rectangular direction polarization component] is the extraordinary index ne of a liquid crystal molecule. Tsunemitsu refractive index n0 It arranges by turns regularly in the rectangular direction of the direction of an electrode stripe, consequently a diffraction grating is formed in a liquid crystal layer, and parallel light can be scattered.

[0107] This example has the composition of acquiring the diffraction-grating effectiveness and the dioptric lens effectiveness as well as an example 14, and as compared with an example 14, the molecular arrangement at the time of no electrical-potential-difference impressing is reverse (it is perpendicular orientation to level orientation), and also let the dielectric constant anisotropy of the used liquid crystal constituent be reverse (just receiving negative). Thus, for LCD of this invention, a refractive index [on the condition of having impressed the electrical potential difference, and as opposed to the direction of an electrode stripe and the polarization component of the rectangular direction] is the extraordinary index ne of a liquid crystal molecule. Tsunemitsu refractive index n0 If it is made to arrange by turns regularly in the fixed direction (more than an one direction), a diffraction grating is formed in a liquid crystal layer, and the effectiveness of scattering parallel light can be acquired. This effectiveness was intersected perpendicularly. If it is made to obtain to the polarization component of a 2-way, the light of unpolarized light can be scattered and a high contrast property will come to be acquired. It is easily realizable if a dielectric constant anisotropy uses a negative liquid crystal constituent for realizing such a configuration in the initial perpendicular orientation where the degree of freedom of the direction of a tilt of a liquid crystal molecule (the direction of a tilt and the tilt down direction) is infinite.

[0108] Thus, it measured by the approach of impressing an electrical potential difference to obtained LCD through TFT, and showing an electro-optics property (permeability-applied-voltage curve) in an example 1. A measurement result is shown in drawing 3232 . In the condition (0V impression) of not impressing the electrical potential difference, the bright permeability property was indicated to be about 80% of permeability. Moreover, applied voltage It is the minimum permeability more than in 3.8V. 0.2% and a

good light-scattering condition were acquired. Moreover, there was no hysteresis in an electro-optics property so that clearly from drawing. Moreover, applied voltage It reaches 3.8V. In 0V, it started, when the speed of response was measured, and 10msec(s), falling 20msec, and a very quick value were acquired.
[0109] The projection mold liquid crystal display was produced using LCD obtained in the example 16 example 15. The structure is shown in drawing 34 . Light source light which makes a metal halide lamp 25 the light source is made into parallel light with the schlieren lens 26, and is projected on a screen 31 by the projection lens unit 30 through a liquid crystal cell 27 and a condenser lens 28. The image inputted into the liquid crystal cell 27 by the driving gear 32 and the video signal output unit 33 is expanded and displayed on a screen 31. LCD of this invention can control the optical path of parallel light by rectilinear propagation or dispersion, and electric field. Therefore, if schlieren optical system is used so that it may illustrate, image display of arbitration can be performed on a screen 31. In this example, in order to project only the light which went straight on among the parallel light which carried out incidence to the liquid crystal cell 31, it is considering as the configuration which intercepted the light which extracted to the location of the focus of a condenser lens 28 (5mmphi), prepared 29, and was scattered by the liquid crystal cell 31.
[0110] The obtained projection mold liquid crystal display is used, and it is abbreviation about the video signal image of monochrome. 30 A contrast ratio is abbreviation when projected twice. 200:1 It turned out that it is a very high value. Moreover, the very bright display was obtained.
[0111] LCD obtained in the example 17 example 15 Three sheets were used and the projection mold liquid crystal display was produced. The structure is shown in drawing 35 . this example -- as the light source -- RGB the source 37 of the white light containing three waves is used, and the spectrum of this is carried out to the wavelength of RGB using the die OKUROIKKU mirrors 34 and 35 and a total reflection mirror 36, respectively -- incidence is carried out to the liquid crystal cells 27a, 27b, and 27c of three sheets. By carrying out like this, it becomes possible to control an optical path for every wavelength. Therefore, color display is realizable. In addition, the die OKUROIKKU mirror 34 makes red wavelength penetrate, carries out total reflection of the wavelength of green and blue, and the die OKUROIKKU mirror 35 makes blue wavelength penetrate, and it carries out total reflection of red and the green wavelength.
[0112] The obtained projection mold liquid crystal display is used, and it is abbreviation about a full color video signal image. 30 A contrast ratio is abbreviation when projected twice. 180:1 It turned out that it is a very high value. Moreover, the very bright display was obtained.
[0113] LCD was obtained by the same approach as an example 15 except having used the substrate with a color filter which formed the poor electrode which consists of ITO on the color filter as an example 18 top substrate and which consists of RGB. The projection mold liquid crystal display was produced with the same configuration as an example 16 using this LCD. Color display is realizable by preparing a color filter.
[0114] The obtained projection mold liquid crystal display is used, and it is abbreviation about a full color video signal image. 30 A contrast ratio is abbreviation when projected twice. 160:1 It turned out that it is a very high value. Moreover, the very bright display was obtained.
[0115]
[Effect of the Invention] LCD which consists of a pneumatic liquid crystal layer of this invention When the conductor section and the non-conductor section are made to counter in some fields in a pixel for every pixel, and width of face of the narrowest part of the non-conductor section is set to S and the electrode spacing of both the substrates by which opposite arrangement was carried out is set to D, it is D>=S/2. Since relation is filled A light-scattering condition is realizable by considering as uniform liquid crystal molecular arrangement with the dioptric lens effectiveness and the diffraction-grating effectiveness by impressing the direction of electric field of the direction of two or more sorts for a light transmission condition. Consequently, LCD excellent in the light-scattering property is obtained without needing media other than liquid crystal. The direction of a tilt at the time of the liquid crystal molecule which forms a liquid crystal layer especially impressing electric field to nothing and a liquid crystal layer in the state of no electrical-potential-difference impressing a spray array When it is the molecular arrangement which can be taken more than a 2-way, the outstanding dispersion property is acquired.
[0116] By making electrode structure into an "embedded structure", "an embedded structure with a clearance", "duplication nesting", "stripe nesting with a clearance", or "duplication stripe nesting", LCD of this invention can form slanting electric field easily so that it may conflict for every detailed field. Consequently, the dispersion property of light is high and LCD excellent in the bright high gradation nature of a contrast ratio with low driver voltage and LCD which has a very large viewing-angle dependency without the viewing angle which a display reverses even if it indicates by gradation are obtained.
[0117] Such effectiveness is maintainable practical by making the particle which has a diameter shorter than

an electrode spacing D mix in both the substrates gap, or preparing a projection shorter than an electrode spacing D at least in one side of both substrates. Furthermore, it is the refractive index of this electrode material on an electrode. 0.9-1.1 When the translucency protective coat which is twice forms, the permeability and contrast at the time of no electrical-potential-difference impressing can be raised.
[0118] The liquid crystal display of this invention can obtain the display with it by applying above-mentioned LCD to especially a projection mold liquid crystal display. [a very high and contrast ratio and] [very bright]

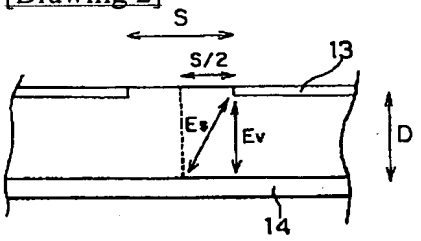
[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

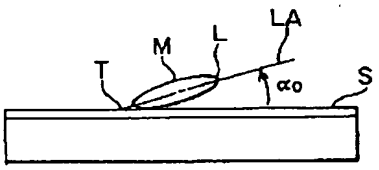
DRAWINGS

[Drawing 2]

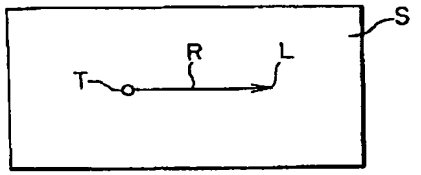


[Drawing 3]

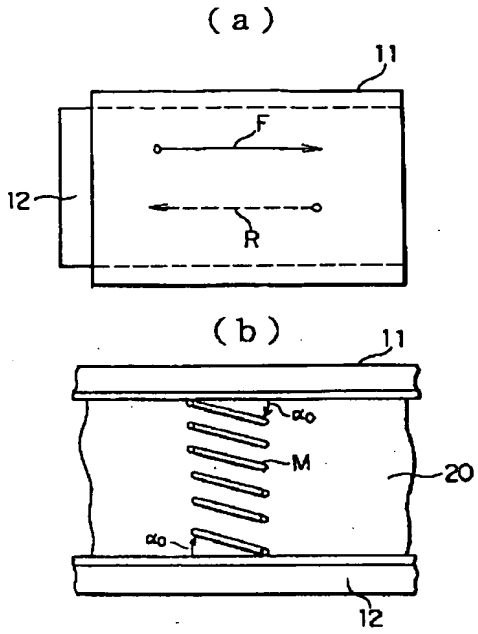
(a)



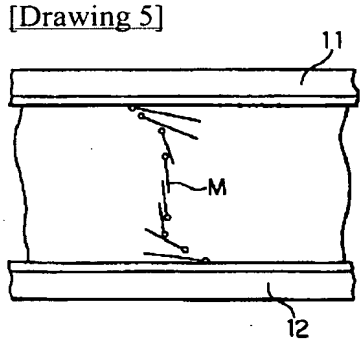
(b)



[Drawing 4]

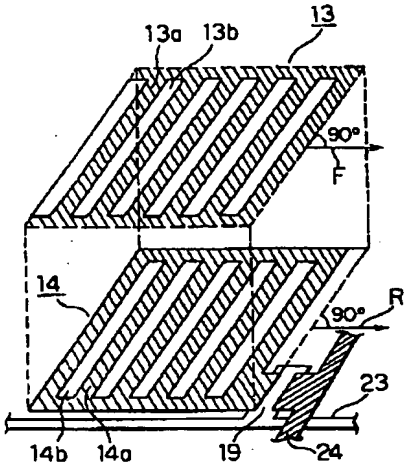


[Drawing 5]



[Drawing 1]

(a)



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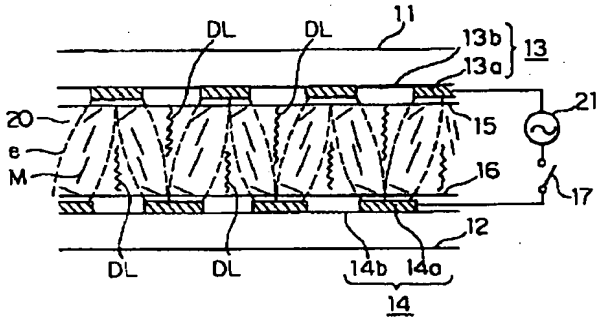
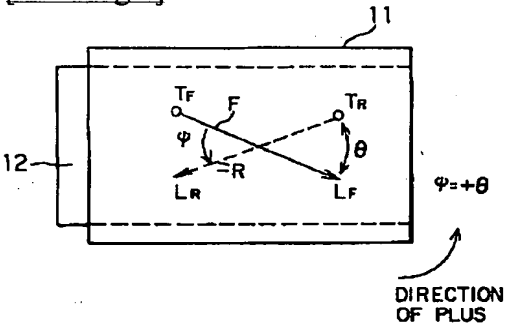
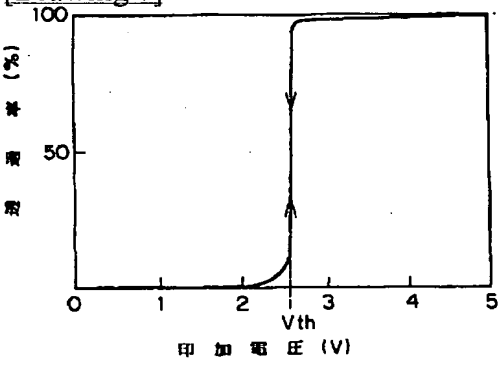


[Drawing 6]



[Drawing 7]



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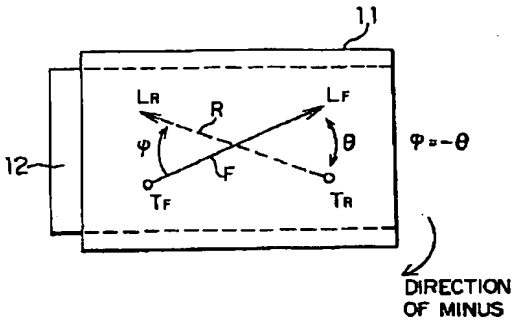

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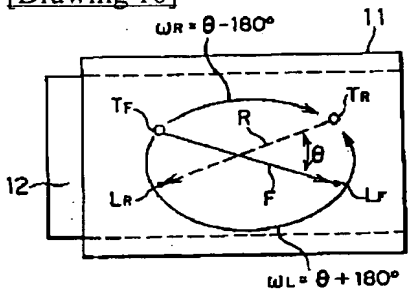

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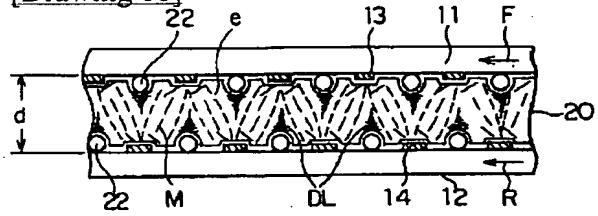

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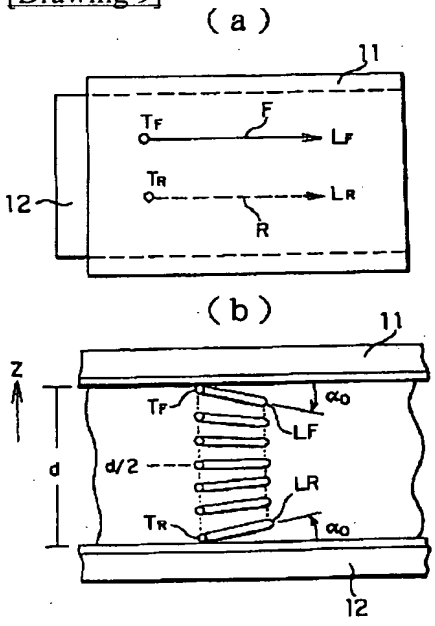
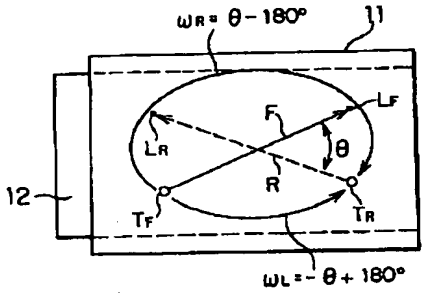


[Drawing 11]



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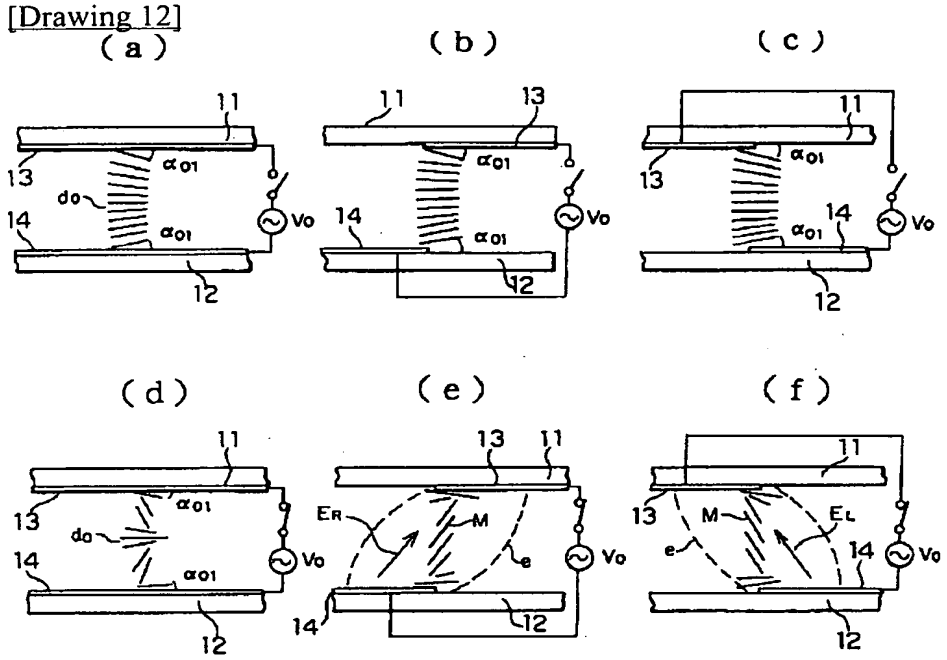

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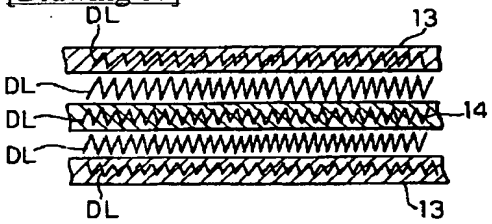

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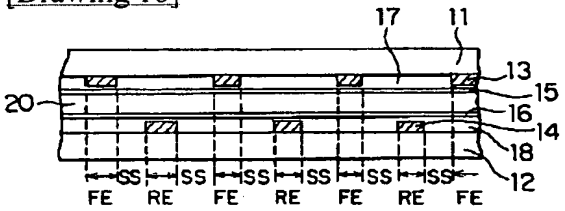

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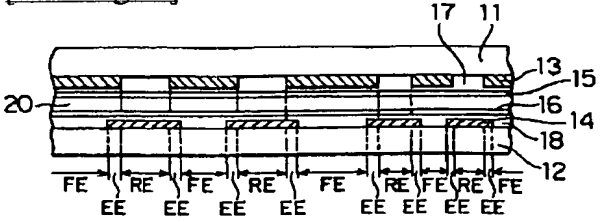
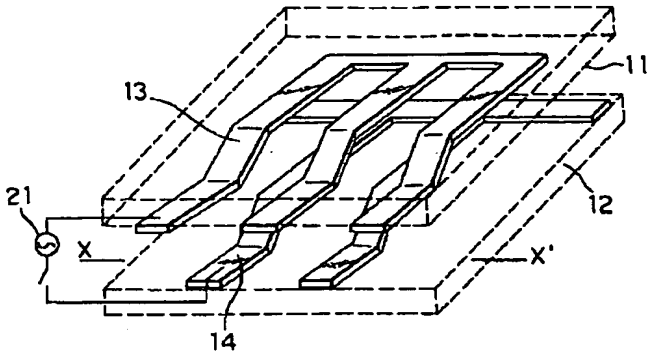


[Drawing 13]

(a)



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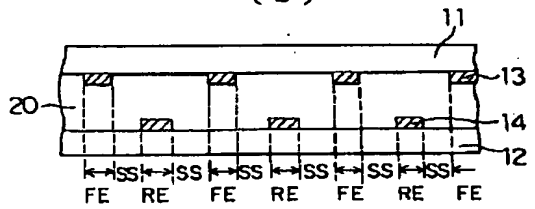

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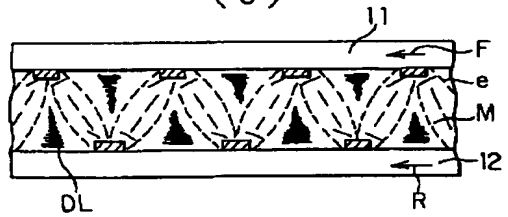

[Drawing 14]

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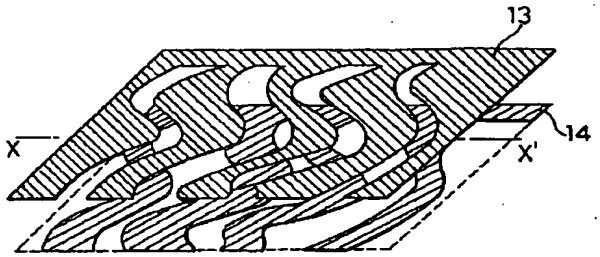

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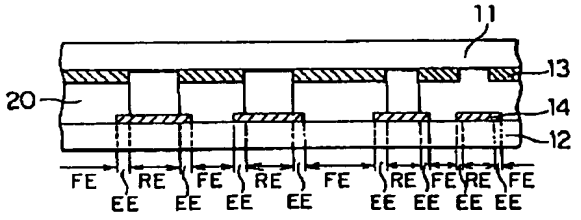

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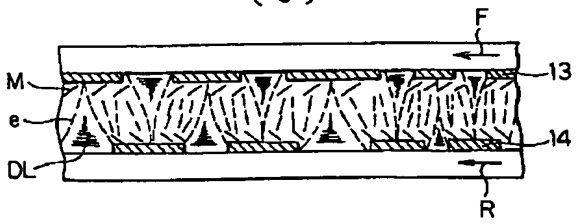
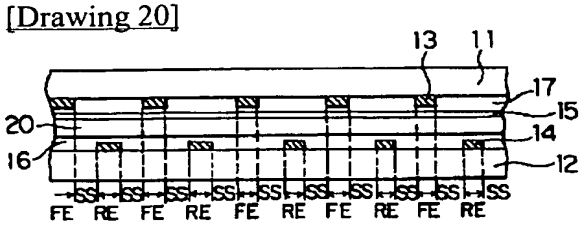


[Drawing 20]



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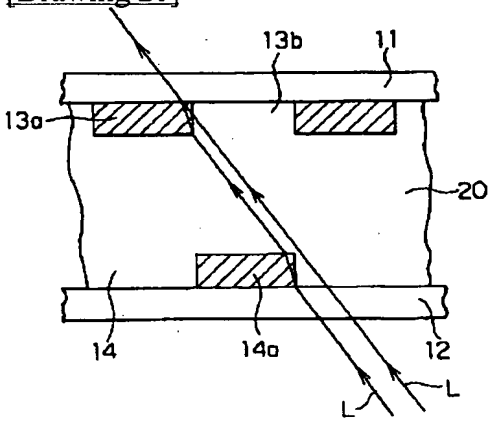

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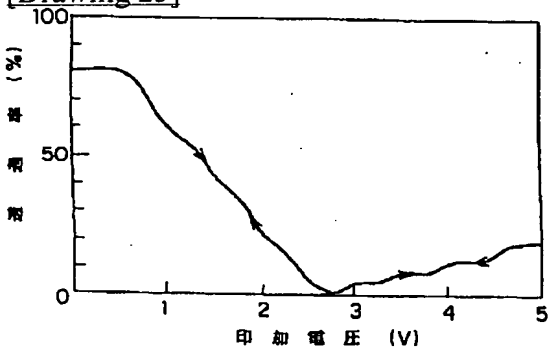
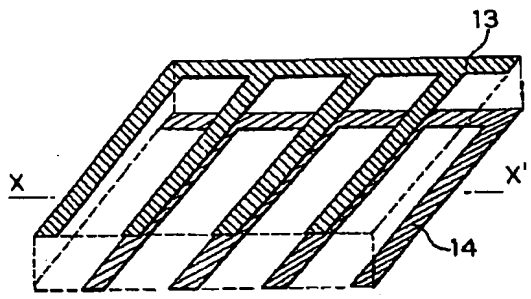


[Drawing 15]

(a)



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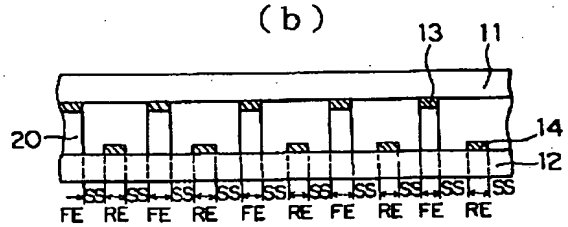

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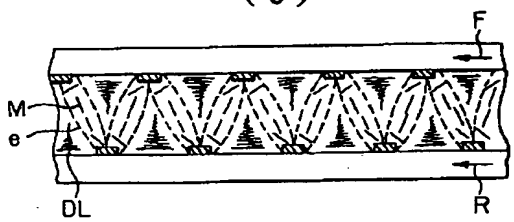

[Drawing 22]

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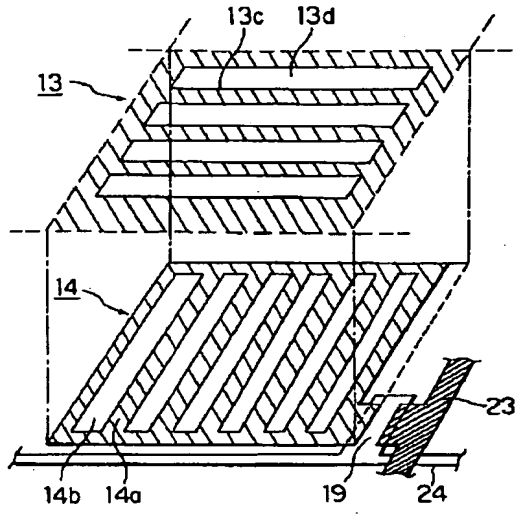

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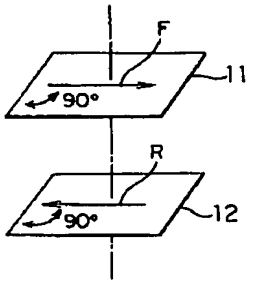
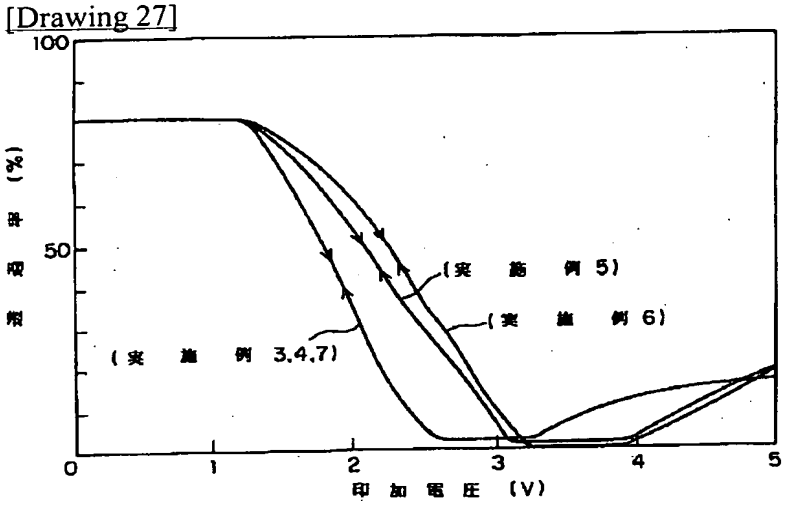
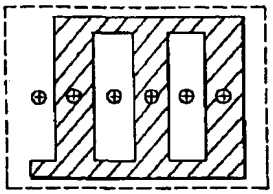


[Drawing 27]



[Drawing 33]

(a)



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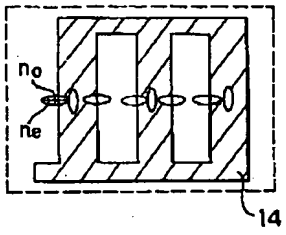
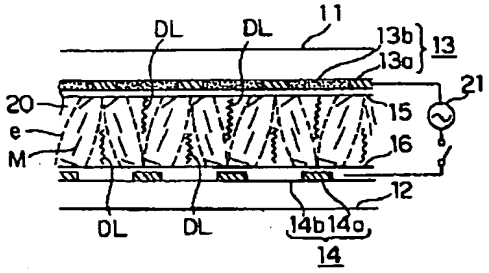


[Drawing 24]

(a)



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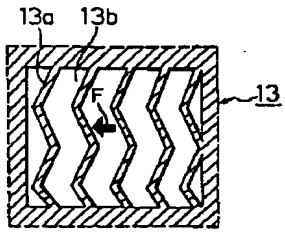

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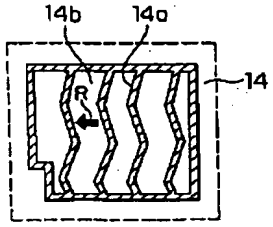
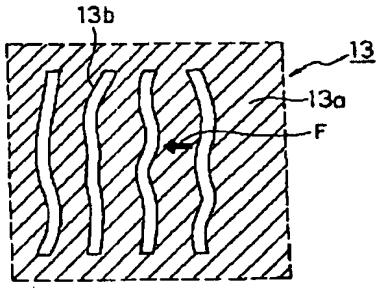


[Drawing 25]

(a)



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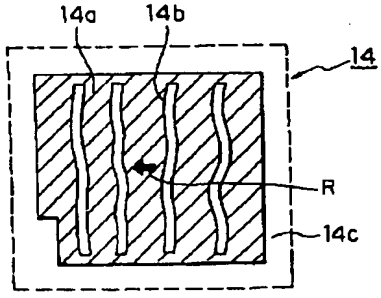
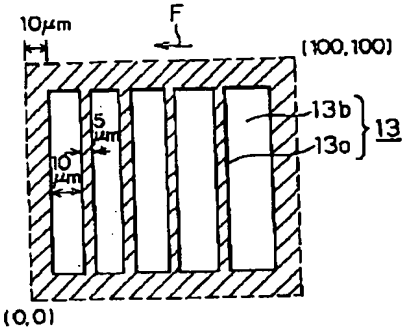


[Drawing 26]

(a)



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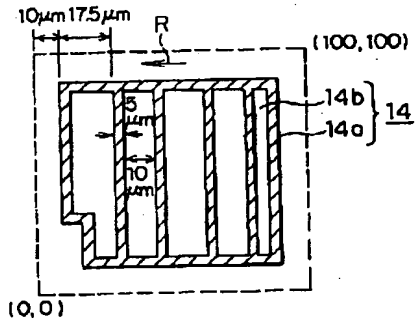
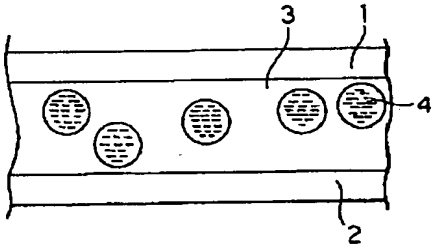


[Drawing 36]

(a)



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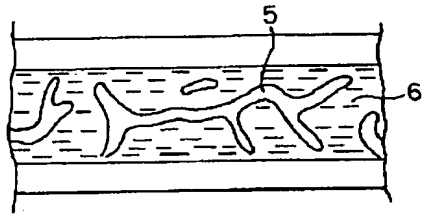
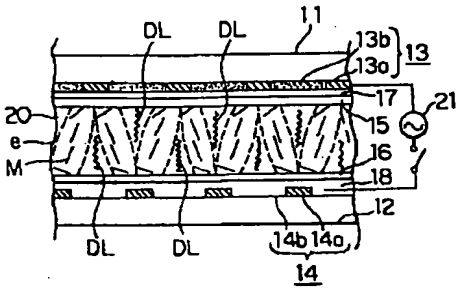


[Drawing 28]

(a)



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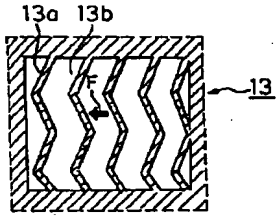

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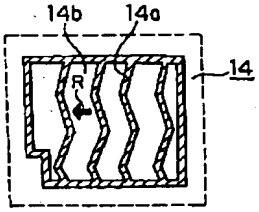
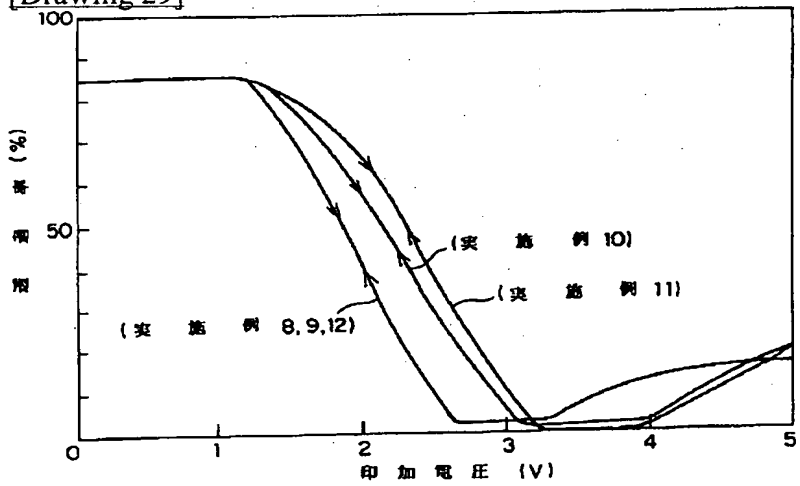
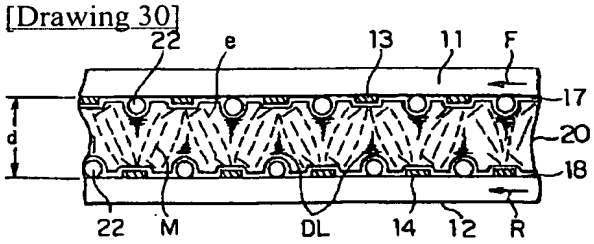


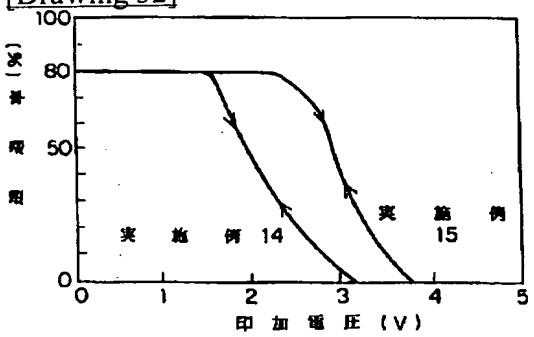
[Drawing 29]



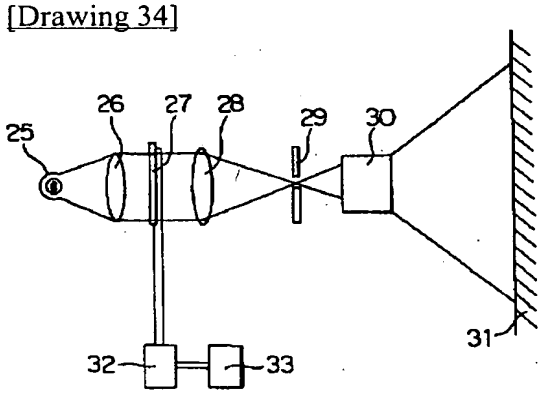
[Drawing 30]



[Drawing 32]



[Drawing 34]



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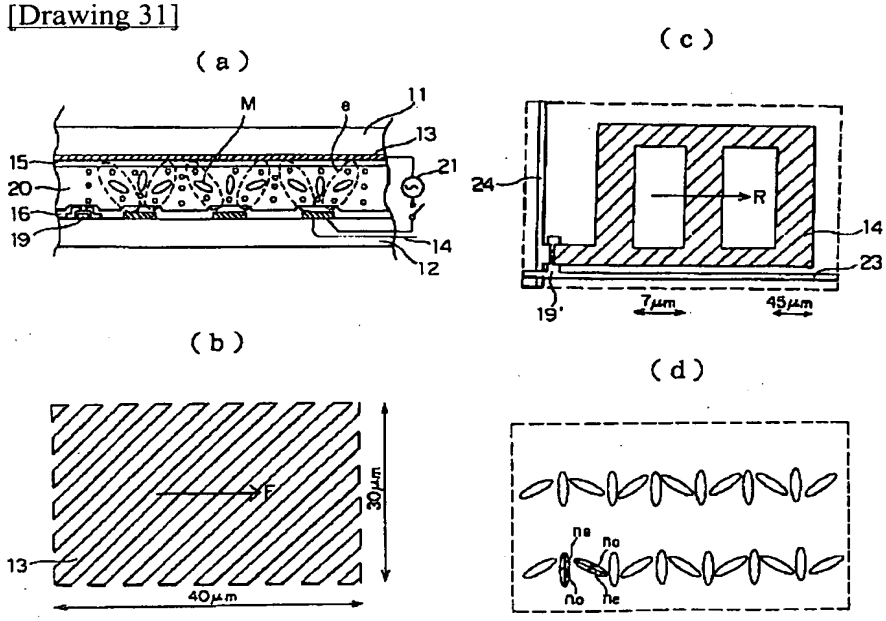
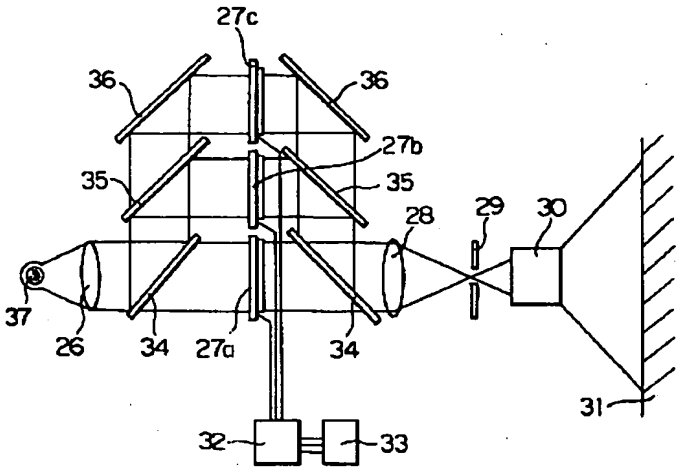


[Drawing 35]



[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（A）**　(11)特許出願公開番号

特開平7－234414

(43)公開日　平成７年(1995)９月５日

(51)Int.Cl.[6]		識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｇ０２Ｆ	1/1343				
	1/133	５００			
	1/1333	５０５			
	1/137				

審査請求　未請求　請求項の数10　ＯＬ　（全 24 頁）

(21)出願番号　特願平6－172935

(22)出願日　平成６年(1994)７月25日

(31)優先権主張番号　特願平5－184273
(32)優先日　平５(1993)７月27日
(33)優先権主張国　日本（ＪＰ）
(31)優先権主張番号　特願平5－237644
(32)優先日　平５(1993)９月24日
(33)優先権主張国　日本（ＪＰ）
(31)優先権主張番号　特願平5－335455
(32)優先日　平５(1993)12月28日
(33)優先権主張国　日本（ＪＰ）

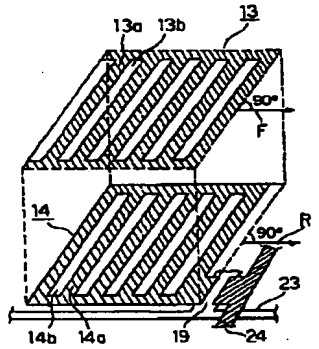
(71)出願人　000003078
株式会社東芝
神奈川県川崎市幸区堀川町72番地
(72)発明者　久武　雄三
神奈川県横浜市磯子区新杉田町８番地　株式会社東芝横浜事業所内
(72)発明者　佐藤　摩希子
神奈川県横浜市磯子区新杉田町８番地　株式会社東芝横浜事業所内
(72)発明者　石川　正仁
神奈川県横浜市磯子区新杉田町８番地　株式会社東芝横浜事業所内
(74)代理人　弁理士　須山　佐一

最終頁に続く

(54)【発明の名称】　液晶表示素子

(57)【要約】
【目的】　光散乱特性が高く、駆動電圧が低く、明るくコントラスト比が高く階調性に優れ、かつ階調表示しても表示が反転することがなく、視野角の極めて広い新規な構成のＬＣＤ。
【構成】　対向配置された電極付き基板と、この基板間に挟持されたネマティック液晶組成物からなる液晶層とからなり、対向配置された電極付き基板の少なくとも一方の基板は、電極構造が 1画素毎に最も広い部分の幅を 50 μm 以下とする導電体部と最も広い部分の幅を 50 μm 以下とする非導電体部とからなる領域を有してなり、対向配置された両基板間において、少なくとも 1画素毎に画素内の一部の領域で導電体部と非導電体部とが対向しており、かつ非導電体部の最も狭い部分の幅をＳとし、対向配置された両基板の電極間隔をＤとしたとき、Ｄ≧Ｓ／2 の関係が満たされている。

（ａ）



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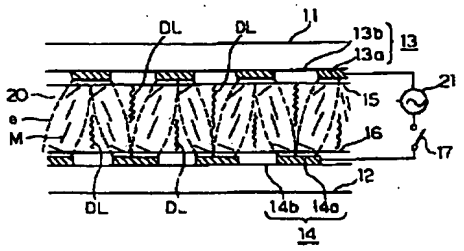

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【特許請求の範囲】

【請求項１】　対向配置された電極付き基板と、この基板間に挟持されたネマティック液晶組成物からなる液晶層とからなる液晶表示素子において、

前記対向配置された電極付き基板の少なくとも一方の基板は、電極構造が 1画素毎に最も広い部分の幅を 50 μm 以下とする導電体部と最も広い部分の幅を 50 μm 以下とする非導電体部とからなる領域を有してなり、

前記対向配置された両基板間において、少なくとも 1画素毎に画素内の一部の領域で前記導電体部と前記非導電体部とが対向しており、かつ前記非導電体部の最も狭い部分の幅をＳとし、前記対向配置された両基板の電極間隔をＤとしたとき、

Ｄ≧Ｓ／2

の関係が満たされていることを特徴とする液晶表示素子。

【請求項２】　請求項１記載の液晶表示素子において、前記液晶層は電界を印加した際のチルト方向が 2方向以上取り得る分子配列を有する液晶組成物からなることを特徴とする液晶表示素子。

【請求項３】　請求項１記載の液晶表示素子において、前記対向配置された両基板間において、この両基板間の垂直法線方向に対して斜め電界が 1画素内に少なくとも 2方向以上形成され、

前記液晶層を形成する液晶分子が電圧無印加状態でスプレイ配列をなし、かつ電圧印加状態でチルトアップまたはチルトダウン方向の自由度を 2方向以上取り得る分子配列であることを特徴とする液晶表示素子。

【請求項４】　請求項１ないし請求項３のいずれか１項記載の液晶表示素子において、

前記対向配置された少なくとも一方の電極付き基板は、前記最も広い部分の幅が 30 μm 以下であり、

前記ネマティック液晶組成物は、前記基板表面上で液晶分子長軸一方向に配列させるチルト配向を誘起する手段を有しており、 2枚の基板上での液晶分子配列方向の交差角をθ（ 0° ≦θ≦90° ）とし、 2枚の基板表面上でのプレチルト角によって液晶をユニフォームツイスト配列させるように決まるセルツイスト角をφとし、前記液晶層に電界を印加しない状態で、

前記φが±θ（ここで、ツイスト方向が左回りの時＋、右回りの時－とする。）のとき、液晶のツイスト角ωが±θ＋ 180° または±θ－ 180° であり、

前記φが±（θ－ 180° ）のとき、液晶ツイスト角ωが±θ（以上、複号同順）であることを特徴とする液晶表示素子。

【請求項５】　請求項１ないし請求項４のいずれか１項記載の液晶表示素子において、

前記対向配置された両基板は、前記両基板電極の素子法線方向での断面形状を見たとき、下基板のみに導電体部を有する幅をＲＥ、および上基板のみに導電体部を有する幅をＦＥ、両基板とも導電体部である幅をＥＥ、両基板とも非導電体部である幅をＳＳとし、少なくとも各画素毎にＲＥ、ＦＥはそれぞれが画素のどこかで電気的にひとつにつながっているとき、

ＲＥ・ＳＳ・ＦＥ・ＳＳ・ＲＥ・ＳＳ・ＦＥ・ＳＳ・…とＳＳを挟んでＲＥとＦＥが交互に順に配置される断面形状となる電極構造であるか、

ＲＥ・ＥＥ・ＦＥ・ＥＥ・ＲＥ・ＥＥ・ＦＥ・ＥＥ・…とＥＥを挟んでＲＥとＦＥが交互に順に配置される断面形状となる電極構造であるか、または

ＲＥ・ＦＥ・ＲＥ・ＦＥ・ＲＥ・ＦＥ・ＲＥ・ＦＥ・…とＲＥとＦＥとが交互に順に配置される断面形状となる電極構造であり、

前記ネマティック液晶組成物は、前記基板表面上で液晶分子長軸を一方向に配列させるチルト配向を誘起する手段を有しており、 2枚の基板上での液晶分子配列方向の交差角がθ（ 0° ≦θ≦90° ）であり、 2枚の基板表面上でのチルト配向によって液晶組成物をユニフォームツイスト配列させるように決まるセルツイスト角がφである液晶表示素子であり、液晶組成物に電界を印加しない状態で、

前記φが±θ（ここでツイスト方向が左回りの時＋、右回りの時－とする。）のとき、液晶のツイスト角ωが±θ＋180 ° または、±θ－180 ° であり、

前記φが±（θ－180 ° ）の時、液晶のツイスト角ωが±θ（以上複号同順）であることを特徴とする液晶表示素子。

【請求項６】　請求項１ないし請求項５のいずれか１項記載の液晶表示素子において、

前記液晶組成物は正または負の誘電率異方性を有する液晶からなり、

電界を印加した際に取り得る 2方向以上のチルト方向は、前記正の誘電率異方性を有する液晶の場合チルトアップ方向であり、前記負の誘電率異方性を有する液晶の場合チルトダウン方向であり、

前記両基板における液晶分子配列は、液晶のプレチルト角の差を 0.5° 以下とする液晶分子配列、プレチルト角α_0が共に90° である垂直配向からなる液晶分子配列またはプレチルト角α_0が共に45° 以上90° 未満であり、かつ上下基板のプレチルト角の差が 0.5° 以下であり、前記プレチルト角α_0を得る方向が上下で同一方向であるベンド状の配向からなるいずれかひとつの液晶分子配列であることを特徴とする液晶表示素子。

【請求項７】　請求項１ないし請求項６のいずれか１項記載の液晶表示素子において、

1画素毎の電極構造が前記両基板ともに各画素の少なくとも一部分で導電体部と非導電体部からなるストライプ状の形状となっていることを特徴とする液晶表示素子。

【請求項８】　請求項１ないし請求項７のいずれか１項記載の液晶表示素子において、

前記両基板間隙に電極間隔Dより短い直径を有する微粒子を混入させるか、または電極間隔Dより短い突起を前記両基板の少なくとも一方に設けてなることを特徴とする液晶表示素子。

【請求項９】　請求項１ないし請求項８のいずれか１項記載の液晶表示素子において、

前記電極上に透光性保護膜が形成され、この透光性保護膜の屈折率が前記電極材料の屈折率の 0.9～1.1 倍であることを特徴とする液晶表示素子。

【請求項１０】　液晶表示素子と、この液晶表示素子に平行光を入射する手段と、前記入射された平行光を前記液晶表示素子にて制御する手段と、前記制御された光の進行方向のうち、一部の方向の光を投影する光学系を用いる手段とからなる投影型液晶表示装置であって、前記液晶表示素子は請求項１ないし請求項９のいずれか１項記載の液晶表示素子であることを特徴とする液晶表示装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、新規な液晶表示素子およびそれを用いた液晶表示装置に関する。

【０００２】

【従来の技術】近年、液晶表示素子（以下、ＬＣＤと略称）はワードプロセッサ、パーソナルコンピュータ、投影型ＴＶ、小型ＴＶ等に広く利用されている。これらのＬＣＤは光の明暗の変化を制御することにより表示を行う。このような光の制御方法として、液晶分子の偏光効果と偏光子との組み合わせによる方法、液晶の相転移を利用して光の散乱と透過による方法、および液晶に染料を添加し、染料の可視光吸収量を制御することで生じた色の濃淡変化を利用する方法等がある。

【０００３】偏光効果と偏光子を組み合わせた方法を用いるＬＣＤは、たとえば90°捻れた分子配列をもつツイステッドネマティック（ＴＮ）型ＬＣＤであり、原理的に薄い液晶層厚、低電圧で偏光を制御できる。このため、ＴＮ型ＬＣＤは、早い応答速度、低消費電力にて、高いコントラスト比特性を示す。このＴＮ型ＬＣＤは、単純マトリクス駆動により、時計や電卓などに、またスイッチング素子を各画素毎に具備したアクティブマトリクス駆動およびカラーフィルターと組み合わせて、フルカラーの表示の液晶ＴＶなどに応用されている。しかし、これら偏光効果と偏光子を組み合わせたＬＣＤは、原理上偏光板を用いることからＬＣＤの透過光量が著しく低くなる。すなわち、少なくとも 1枚の偏光板を用いるため、透過光量は少なくとも50%以下となる。また液晶分子配列の方位性により見る角度・方位によって表示色やコントラスト比が大きく変化するため、視角依存性を有する。この視角依存性に加え、入射光量に対する透過光量の比で示される透過率が低いなどの理由により、ＴＮ型ＬＣＤは冷陰極線管（ＣＲＴ）の表示性能を完全に越えるまでには至っていないのが実状である。

【０００４】一方、液晶の相転移を利用したＬＣＤ、および染料の可視光吸収量を制御したＬＣＤは、たとえば、ヘリカル構造の分子配列をもつコレステリック相からホメオトロピック構造の分子配列をもつネマティック相への相転移を電場印加で生じさせるＰＣ型液晶およびこの液晶分子に染料を添加してなるホワイト・テーラー型ＧＨ液晶を用いるＬＣＤ等である。これらのＬＣＤは原理上偏光板を用いないので透過率が低くなることがない。また広い視認角を示すので、自動車機器や、投影型表示器等に応用されている。

【０００５】しかし、このようなＬＣＤは、液晶層厚を比較的厚くしたり、液晶分子のヘリカル強度を強めたりしないと充分な光の散乱が得られない。これは光の散乱が種々の液晶分子配列に因っているからである。つまり、充分に光を散乱させるためには、たとえば、ヘリカル構造の分子配列をもつコレステリック相の場合、入射光方向に対し、あらゆる方位にヘリカル軸をもつ必要性が生じる。このように、多数の方位のヘリカル軸をもたせるためには、液晶層厚を厚くしなくてはならない。このため、このようなＬＣＤは、高い駆動電圧を要し、応答速度が極めて遅いという問題があり、表示量（画素数）の多い表示素子への応用は困難であった。　また、印加電圧の増加に伴い、透過率が急激に変化するために階調表示も困難であった。さらに、光散乱状態と光透過状態とで液晶の分子配列が著しく異なるため、光散乱および光透過状態の相互変化を電界制御で行う場合、その電気光学特性にヒステリシスが生じてしまう。このヒステリシスが生じる原因には諸説があり明確にされていないが、液晶の分子配列が著しく異なる場合や、電界が印加されていない状態で光散乱状態（液晶の分子配列が微細なドメインの集合体となっている状態）を液晶分子が形成している場合に発生しやすいことが知られている。このように、その印加電界ー透過率特性にヒステリシスがあると、マルチプレクス駆動が困難になるなど実用的に問題があった。

【０００６】液晶の相転移を利用した他のＬＣＤに、有機電解質等の導電性物質を溶解したＮｎ液晶を用い、低周波で高電圧を印加することにより光散乱を得る手段（一般にＤＳ効果という）や熱光学効果により光散乱を得る手段を用いるＬＣＤが提案されている。しかし、この場合においても上述の問題がある。

【０００７】さらに、図３６（ａ）に示すように、基板１、２間で挟持されたポリマー３内に多数のカプセルを形成して、この中に液晶４を封入したカプセル状構造、および図３６（ｂ）に示すように、繊維状ポリマー５の間に液晶６を分散させた繊維状ポリマー構造を用いて光散乱性を高める高分子分散型ＬＣＤが提案されている。しかし、このような高分子分散型ＬＣＤは、製法上および原理上から、そのポリマーの形状やポリマーと液晶層

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との混合比に制約がある。また外部から印加した電圧はポリマーと液晶とに分圧されるため、液晶には印加電圧の一部しか印加されない。このため、充分に低い駆動電圧と高い応答速度などが要求される駆動特性を満足させようとすると、充分な光散乱性を得られないのが現状である。また、これらの方式においても、光散乱状態と光透過状態とで液晶の分子配列が著しく異なるため、前述したように電気光学特性にヒステリシスが生じてしまう。これに対し光散乱状態における液晶分子配列をある程度制御（たとえば、カプセル内面における液晶分子配列を制御するためにポリマーに疎水性の物質を混合する等）し、前記ヒステリシスを軽減させることも可能であるが、このことは同時に光散乱を弱めることとなり、実用的でない。このように、高分子分散型ＬＣＤにおいても、液晶の相転移を利用した他のＬＣＤと同様な問題があった。

【０００８】光を散乱させる手法として、 2枚の電極付基板の表面において種々の方向に液晶分子を配列させるよう微細な領域毎に配向処理を行い、これらを内面として対向させた間隙に液晶を挟持させることも考えられる。しかし、微細な領域毎に配向処理方向（たとえばラビング方向）を異ならせることは実際上困難であり、また、前述のヒステリシスの問題を解決する手段とはならない。

【０００９】

【発明が解決しようとする課題】前述したように、従来のＬＣＤは透過率が低く、狭い視角依存性を有するか、または高い駆動電圧を要し、応答速度も遅いといった問題をもっていた。本発明は、このような課題に対処するためになされたもので、光散乱特性が高く、駆動電圧が低く、明るくコントラスト比が高く階調性に優れ、かつ階調表示しても表示が反転することがなく、視野角の極めて広い新規な構成のＬＣＤを提供することを目的とする。

【００１０】

【課題を解決するための手段】本発明のＬＣＤは、光を散乱させる手段として、液晶以外の媒体を必要とせず、なおかつ、光透過状態と光散乱状態とで液晶の分子配列が著しく異ならず、良好な光散乱状態を得ることのできる構成としたものである。さらに、複雑な製造工程によらずＬＣＤを製造することができる構成でもある。

【００１１】本発明のＬＣＤは、対向配置された電極付き基板と、この基板間に挟持されたネマティック液晶組成物からなる液晶層とからなり、対向配置された電極付き基板の少なくとも一方の基板は、電極構造が 1画素毎に最も広い部分の幅を 50 μm 以下とする導電体部と最も広い部分の幅を 50 μm 以下とする非導電体部とからなる領域を有してなり、対向配置された両基板間において、少なくとも 1画素毎に画素内の一部の領域で導電体部と非導電体部とが対向しており、かつ非導電体部の最

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も狭い部分の幅をＳとし、対向配置された両基板の電極間隔をＤとしたとき、Ｄ≧Ｓ／2 の関係が満たされていることを特徴とする。

【００１２】このＬＣＤにおいて、液晶層は電界を印加した際のチルト方向が 2方向以上取り得る分子配列を有する液晶組成物からなることを特徴とする。また、対向配置された両基板間において、この両基板間の垂直法線方向に対して斜め電界が 1画素内に少なくとも 2方向以上形成され、液晶層を形成する液晶分子が電圧無印加状態でスプレイ配列をなし、かつ電圧印加状態でチルトアップまたはチルトダウン方向の自由度を 2方向以上取り得る分子配列であることを特徴とする。

【００１３】具体的に本発明は、対向配置された少なくとも一方の電極付き基板は、最も広い部分の幅が 30 μm 以下であり、ネマティック液晶組成物は、基板表面上で液晶分子長軸一方向に配列させるチルト配向を誘起する手段を有しており、 2枚の基板上での液晶分子配列方向の交差角を θ （ $0° \leqq \theta \leqq 90°$ ）とし、 2枚の基板表面上でのプレチルト角によって液晶をユニフォームツイスト配列させるように決まるセルツイスト角を ϕ とし、液晶層に電界を印加しない状態で、ϕ が $\pm\theta$ （ここで、ツイスト方向が左回りの時＋、右回りの時－とする。）のとき、液晶のツイスト角 ω が $\pm\theta + 180°$ または $\pm\theta - 180°$ であり、ϕ が $\pm(\theta - 180°)$ のとき、液晶ツイスト角 ω が $\pm\theta$ （以上、複号同順）であることを特徴とする。

【００１４】また、本発明の他の具体例として、対向配置された両基板は、両基板電極の素子法線方向での断面形状を見たとき、下基板のみに導電体部を有する幅をＲＥ、および上基板のみに導電体部を有する幅をＦＥ、両基板とも導電体部である幅をＥＥ、両基板とも非導電体部である幅をＳＳとし、少なくとも各画素毎にＲＥ、ＦＥはそれぞれが画素のどこかで電気的にひとつにつながっているとき、

ＲＥ・ＳＳ・ＦＥ・ＳＳ・ＲＥ・ＳＳ・ＦＥ・ＳＳ・…とＳＳを挟んでＲＥとＦＥが交互に順に配置される断面形状となる電極構造であるか、

ＲＥ・ＥＥ・ＦＥ・ＥＥ・ＲＥ・ＥＥ・ＦＥ・ＥＥ・…とＥＥを挟んでＲＥとＦＥが交互に順に配置される断面形状となる電極構造であるか、または

ＲＥ・ＦＥ・ＲＥ・ＦＥ・ＲＥ・ＦＥ・ＲＥ・ＦＥ・…とＲＥとＦＥとが交互に順に配置される断面形状となる電極構造であり、ネマティック液晶組成物は、基板表面上で液晶分子長軸を一方向に配列させるチルト配向を誘起する手段を有しており、 2枚の基板上での液晶分子配列方向の交差角が θ （ $0° \leqq \theta \leqq 90°$ ）であり、 2枚の基板表面上でのチルト配向によって液晶組成物をユニフォームツイスト配列させるように決まるセルツイスト角が ϕ である液晶表示素子であり、液晶組成物に電界を印加しない状態で、ϕ が $\pm\theta$ （ここでツイスト方向が左回

りの時＋、右回りの時－とする。）のとき、液晶のツイスト角ωが±θ＋180°または、±θ－180°であり、φが±（θ－180°）の時、液晶のツイスト角ωが±θ（以上複号同順）であることを特徴とする。

【００１５】本発明に係わる液晶組成物および液晶分子配列としては、液晶組成物は正または負の誘電率異方性を有する液晶からなり、電界を印加した際に取り得る 2方向以上のチルト方向は、正の誘電率異方性を有する液晶の場合チルトアップ方向であり、負の誘電率異方性を有する液晶の場合チルトダウン方向であり、両基板における液晶分子配列は、液晶のプレチルト角の差を 0.5°以下とする液晶分子配列、プレチルト角α_0が共に90°である垂直配向からなる液晶分子配列またはプレチルト角α_0が共に45°以上90°未満であり、かつ上下基板のプレチルト角の差が 0.5°以下であり、前記プレチルト角α_0を得る方向が上下で同一方向であるベンド状の配向からなるいずれかひとつの液晶分子配列であることを特徴とする。

【００１６】本発明に係わる電極構造は、 1画素毎の電極構造が両基板ともに各画素の少なくとも一部分で導電体部と非導電体部からなるストライプ状の形状となっていることを特徴とする。さらに、少なくとも一方の前記電極付き基板の 1画素毎にスイッチング素子を有することが好ましい。

【００１７】本発明のＬＣＤは、両基板間隙に電極間隔Ｄより短い直径を有する微粒子を混入させるか、または電極間隔Ｄより短い突起を前記両基板の少なくとも一方に設けてなることを特徴とする。さらに、電極上に透光性保護膜が形成され、この透光性保護膜の屈折率が電極材料の屈折率の 0.9～1.1 倍であることを特徴とする。

【００１８】本発明の液晶表示装置は、ＬＣＤに平行光を入射する手段と、この入射された平行光をＬＣＤにて制御する手段と、制御された光の進行方向のうち、一部の方向の光を投影する光学系を用いる手段とからなる投影型液晶表示装置であって、ＬＣＤとして上述の本発明のＬＣＤを使用することを特徴とする。

【００１９】さらに、本発明のＬＣＤを 2以上用い、それぞれに赤色、青色、緑色の少なくともいずれか 1色を含む分光された平行光を入射するか、または 1個のＬＣＤに2色以上のカラーフィルターを具備することにより、カラー表示することが好ましい。

【００２０】

【作用】本発明のＬＣＤは新規な液晶セル構成により光を制御するものである。以下、本発明において光を制御する原理について説明する。本発明のＬＣＤは、各画素において、実効的に一様な分子配列とすることにより光透過状態を実現し、また 2種以上の電界方向をもって、屈折レンズ効果や回折格子効果を得ることにより光散乱状態を実現する。ここで、屈折レンズ効果とは、液晶層厚方向に液晶分子が連続的に傾きを変え液晶層の屈折率が連続的に変化することにより入射した光を屈折させる効果をいう。また、回折格子効果とは、液晶分子の異常光屈折率n_eと常光屈折率n_oとが液晶平面において規則的に交互に出現することにより液晶層に回折格子が形成され、その結果平行光が散乱する効果をいう。このような屈折レンズ効果や回折格子効果による光散乱は、 2種以上の電界方向の境界部にウォール（壁）状の分子配列を形成することにより得られる。

【００２１】本発明のＬＣＤの一画素における分子配列構造の一例を図１（ｂ）に示す。この図１（ｂ）に示す分子配列構造は、スプレイ配列およびそれに捩じれを加えた分子配列であり、なおかつ上下基板表面における液晶分子プレチルト角が上下でほぼ等しいことを特徴としている。また電圧を印加した場合の分子配列構造を示している。すなわち、上、下基板１１、１２にそれぞれ画素単位で複数のストライプを形成する電極１３、１４を配置し、各電極の導電部１３ａ、１４ａと非導電部１３ｂ、１４ｂを等間隔とし、 1/2ピッチずらして対向させる。上、下配向膜１５、１６の配向方向を同じ方向とし、液晶層２０の液晶分子Ｍをスプレイ配列としている。

【００２２】上下電極１３、１４に電圧を印加すると、横方向電界ｅが発生する。こうした分子配列では電界の印加の仕方によってはその分子のチルト方向が図示するごとく、 2方向となる。これは電圧を印加しない状態での液晶分子配列が液晶層の上半分と下半分で対称な形をしていることによっている。つまりは、液晶分子のチルト方向が 2以上の自由度をもっていることによる。よって、電圧を印加すると図示するように、分子のチルト方向の境界部（図中ＤＬ）にウォールライン（本発明では、電界印加時に発生する発生するメモリー性の強い一般的な意味でのディスクリネーションと区別するために「ウォール」と称する。）を発生させることができ、入射光を散乱させる機能を得ることができる。このように、液晶分子のチルト方向が 2以上の自由度をもたせるには図１（ｂ）の分子配列構造の他、たとえば、液晶組成物として負の誘電率異方性をもつネマティック液晶組成物を用い、液晶分子配列を上下基板におけるプレチルト角が90°である完全な垂直配列としても同様の効果を得ることができる。この場合、液晶分子のチルトダウン方向の自由度が 2以上となる。

【００２３】いずれにせよ、このように液晶分子が電圧を印加していない状態で実効的に一様な分子配列であり、液晶分子のチルトアップ方向、もしくはチルトダウン方向の自由度が 2以上である液晶分子配列に対し、斜め電界が微細な領域毎に相反する 2方向以上に印加されるように考慮した電極であれば、前述した問題を解決した優れた表示性能を得ることができる。

【００２４】ここで斜め電界を有効に実現するためには、非導電体部の最も狭い部分の幅をＳとし、対向配置

された両基板の電極間隔をDとしたとき、D≧S／2 の関係が満たされていることが必要条件となる。以下、その理由を図２により説明する。図２は本発明に用いる電極構造の一断面図である。図２において、最も弱い電界はＥｓであり、この電界強度が斜め電界の強弱を決める。そして、この斜め電界強度の大きさにより屈折レンズ効果や回折格子効果に影響を与える液晶分子の配列が制御される。実験の結果、Ｅｓの電界強度がＥｖの (2)1/2 ／2 未満において有効に光制御できることが分かった。よってＥｓ≧ (2)1/2 ／2 Ｅｖが必要条件となり、これを実現するにはD≧S／2 となる。DおよびSをこの範囲で設定すれば、Sの領域にある液晶分子も必要十分に電界により制御され、チルト方向や配列方位を制御することができる。

【００２５】本発明は、液晶をユニフォームツイスト配列させない場合に、横電界成分をもつ印加電圧の有無によって液晶分子の向きが変化することを利用して光散乱効果を高めるようにしたものである。このため、電極の微小領域内に導電体部と非導電体部を形成し、基板間で、液晶層を挟んで相対向する一方の電極の導電体部と他方の電極の非導電体分を対面させたものである。

【００２６】本発明の作用を説明する前提として、プレチルト角、ユニフォームツイスト配列、非ユニフォームツイスト配列について述べる。ネマティック液晶の分子は細長い棒状をなしている。液晶分子が基板上のラビングした配向膜に接すると、その棒状分子の長軸が配向膜表面の性質により一定方向に配向する。たとえば、配向膜がポリイミド配向膜等の場合は、ラビングした方向に沿って液晶分子長軸が並んで配向される。また、ポリスチレン配向膜等の場合は、膜平面方向においてラビング方向に直角な方向に液晶分子長軸が並ぶ。また、別の配向処理の方法として配向膜を基板に蒸着する方法がある。基板面に対して酸化珪素をたとえば入射角 85° で斜めから蒸着すると、蒸着源の方向に液晶分子の長軸が向く。

【００２７】しかし、実際はこれらの配向処理において、液晶分子Mは配向膜面Sに平行に配向されるのではなく、図３（ａ）のように配向膜面すなわち基板面Sに対してチルト配向により、ある所定の角度α_0で起き上がって配向している。この角度α_0はポリイミド配向膜で約 1～15° である。この基板面上において基板面と接する液晶分子の長軸ＬＡとのなす角α_0をプレチルト角という。このとき、図３（ａ）に示されるように、液晶分子長軸ＬＡの基板から起き上がった端部をリーディング部分Ｌ、基板側に接近する端部をトレーリング部分Ｔとすると、配列された液晶分子Mを説明上、図３（ｂ）のように、たとえば配向膜平面上にＴからＬ方向への矢印Ｒで表すこととする。

【００２８】図４（ａ）の例では、フロント基板すなわち上基板１１の分子配列をＦ（実線の矢印）となるようにして、リア基板すなわち下基板１２の分子配列をＲ（破線の矢印）となるように配向処理をした場合であり、各配列は基板平面上で逆方向すなわち 180° 異なる方向に向いている。この構成において、液晶分子が捩じれを有しないような誘電率異方性が正のネマティック液晶（たとえばカイラル剤未混入）を充填すると、液晶分子Mは図４（ｂ）のように、上基板１１から下基板１２にかけて、液晶層２０の厚さ全長にわたって、一定かつ一様な角度で配列する。一般に、このような分子配列をユニフォーム配列といい、従来のＬＣＤの基本的な構成である。この構成のＬＣＤでは、液晶層に閾値電圧以上の電圧すなわち駆動電圧が印加されると、両基板表面近傍の液晶分子の傾く方向に準じて液晶分子Mが図５のように基板に対してほぼ垂直な方向に一様に配列する。

【００２９】図６は図４（ａ）の状態から、上基板１１を基準にして、下基板１２を角θ（≦90°）捩じった状態の場合を想定した図である。このときの分子配列がユニフォーム配列を維持するには、両基板間で液晶が角ϕだけ左回り（図中矢印の回転方向）に捩じれた配列をとる必要があり、これを実現するには角ϕだけ捩じれるように液晶材料を選定すればよい。このようにして得た分子配列は捩じれたユニフォーム配列と呼ぶことができ、この場合、この角ϕをユニフォーム配列のツイスト角という。ちなみに従来技術であるＳＴ－ＬＣＤはこのϕを 90° ～ 270° とした捩じれたユニフォーム配列をしている。

【００３０】図７はϕが 180° のＳＴ－ＬＣＤにおける印加電圧に対するＬＣＤの透過率の関係を示したものである。この図から、ＳＴ－ＬＣＤはある電圧、つまり閾値電圧V_{th}以上で透過率を急峻に変化することとなる。このことから、ＳＴ型のＬＣＤは閾値電圧以下の印加電圧下では、電圧無印加の状態に近い分子配列をなしていると考えられ、このＳＴ－ＬＣＤのように液晶の捩じれ角が90° 以上 270° 以下のＬＣＤの分子配列を定義するときは、この閾値電圧以下の印加電圧状態下（無印加時）で定義することになる。また、こうした透過率－印加電圧特性（図７の曲線）において、その特性の急峻性を一般的には、透過率90％と10％となる印加電圧値の差を透過率90％の印加電圧の値で割った値γで表す。この構成のＬＣＤでは、前述した捩じれのないユニフォーム配列の場合と同様に液晶層に閾値電圧以上の電圧が印加されると（電圧印加時）、両基板表面近傍の液晶分子の傾く方向に準じて液晶分子Mが図５の配列を捩じったように基板に対してほぼ垂直な方向に配列する。

【００３１】図６からわかるように、ユニフォーム配列のツイスト角ϕは上基板の配向Ｆの液晶分子のトレーリング部分T_Fを基準にして、下基板の配向Ｒの液晶分子のリーディング部分L_Rまでの角度を表している。ϕは、図６のように左回りを＋θと、図８のように右回りを－θと 2通りに定義できる。

【００３２】一方、図９（ｂ）のような液晶分子の配列も可能である。このような配列は、前述した図４（ｂ）の配列同様、捩じれを生じさせないネマティック液晶組成物を図９（ａ）の構成下に維持すれば達成できる。

【００３３】こうした分子配列は、上下基板の分子配列Ｆ、Ｒが同方向にあり、図９（ｂ）のように、分子配列は液晶分子のチルト角が上基板１１のプレチルト角α_0から徐々に角度が減少し、液晶層厚ｄの中点ｄ／２で基板１１と平行になった後、下基板１２のプレチルト角α_0に至るまで逆の角度に傾いていくようになっているものである。すなわち、リーディング部分L_F、L_Rが互いに近接し、トレーリング部分T_F、T_Rが互いに離れて配列する。このような非ユニフォーム配列をスプレイ配列という。

【００３４】つぎに、このスプレイ配列に前述したユニフォーム配列同様、捩じれを加えた構造を得ることを考える。図１０のように、図６のユニフォーム配列と同じく上基板１１の配向Ｆに対して下基板１２の配向Ｒをθだけ交差した状態でスプレイ配列とすることを考えると、図１０に示すように、上基板１１の配向Ｆのトレーリング部分T_Fから下基板の配向Ｒのトレーリング部分T_Rとのなす角度で液晶分子が捩じれていなければならないこととなる。スプレイ配列におけるこのツイスト角をωとすると、図１０の左回りにωをとると、ωは正であるから、スプレイ配列ツイスト角ωＬは（θ＋180°）となり、右回りにωをとるとωは負であるから、スプレイ配列ツイスト角ωＲはその補角である（θ－180°）となる。また、図１１のような構成を考えると、右回りにωをとると、ωは負であるから、スプレイ配列ツイスト角ωＲは（$-\theta$－180°）となり、左回りにωをとると、ωは正であるから、スプレイ配列ツイスト角ωＬはその補角である（$-\theta$＋180°）となる。

【００３５】このように図１０、１１の構成では、スプレイ配列ツイスト角ωは（$\pm\theta$＋180°）と（$\pm\theta$－180°）の4通りのツイスト状態のいずれかをとることができる。以上のようにスプレイ配列においても、ユニフォーム配列時のツイスト角ϕの＋θ、－θに対応して、それぞれ捩じれ配列が実現できる。

【００３６】図１０、図１１で説明した各ωは、ユニフォームツイスト配列をさせた場合のツイスト角ϕを考えると、それぞれϕ＝＋θ、－θとなり、角θが$0 \leqq \theta \leqq 90°$の範囲では、ϕが$\pm\theta$のとき捩じれたスプレイ配列を実現するには、そのツイスト角ωがそれぞれ（$\pm\theta$＋180°）、（$\pm\theta$－180°）でなければ成立しないことを意味する。この場合にωの取り得る値の範囲は、$\omega = |\theta \pm 180°| = 90° \sim 270°$となり、このツイスト角は従来のＳＴ－ＬＣＤの実用解と一致する。つまり、捩じれたスプレイ配列であって、従来のＳＴ－ＬＣＤのツイスト角に等しいツイスト角を得ることを考えると、ユニフォーム配列のツイスト角ϕが$\pm\theta$であって液晶のツイスト角ωが（$\pm\theta$＋180°）または（$\pm\theta$－180°）となる。この構成が本発明のＬＣＤの第１の特徴となる。こうしたスプレイ配列は、上下基板表面における液晶分子の傾く方向（プレチルト方向）が、上基板、下基板それぞれの表面の液晶分子同士が逆の方向になる。したがって、液晶層全体でみると、電圧を印加したときの液晶分子のチルト方向は上基板または下基板表面のチルト方向に依存するため 2通りあることになる。　このため、斜め電界が 2通りの方向に印加された場合、液晶分子は容易に 2通りの方向にチルトすることができ、本発明の効果である光散乱効果を容易に得ることができるわけである。

【００３７】反対に前記ユニフォーム配列を用いた場合、プレチルト方向は上下基板とも実効的に同一方向となるので、分子配列上は 1通りのチルト方向しか得ることができない。このため、液晶分子を 2通りの方向にチルトさせるには、極めて強い斜め電界を印加する必要があり、実用的でない。ユニフォーム配列では、発明者等の実験結果によると、本実施例の電極構成によっても60Ｖ以上の電圧を印加しなければウォールによる光散乱効果が得られない。

【００３８】このように液晶分子配列上、液晶分子のチルト方向が 2通りとなるものは、上述のスプレイ配列の他、下記の 2通りである。一つは上下基板のプレチルト角α_0が共に90°である完全な垂直配向の液晶分子配列である。この場合、液晶組成物としては負の誘電率異方性の材料を用いる。　この負の誘電率異方性を示す液晶組成物に電圧を印加すると、液晶分子は電界方向と直交する方向にチルトする。したがって、本発明による電極構成のように 2つの方向からなる斜め電界を印加すると、液晶分子が 2方向にチルト（チルトダウン）する。すなわち、上下基板のプレチルト角α_0が共に90°であることは、上下基板表面の液晶分子に基板平面方向の方向がないことを意味するため、チルト方向には全く制約がない。この場合の液晶分子のチルト方向の自由度は無限にある。

【００３９】他は負の誘電率異方性の液晶組成物を用いて上下基板で液晶分子の垂直方向からの傾きが同一方向のプレチルト方向を有する分子配列（一般にベンド配列という）の場合である。この場合はチルトダウンする方向が 2通り以上生じる。すなわち自由度が 2以上ある。

【００４０】しかし、負の誘電率異方性の液晶組成物を用いても、液晶分子が垂直方向（90°）からやや傾いて、上下基板でユニフォームチルト配列をなす場合は、自由度が 1になってしまい、本発明の対象外である。

【００４１】こうした本発明のＬＣＤの分子配列を概念的に示すと図１２のようになる。この液晶分子の捩じれ方向、捩じれ度合いは、液晶に混ぜるカイラル液晶剤の種類、混合量により制御することができる。具体的な材料としては、左回りカイラル剤にオクチル-2- オキシ -

4-(4´-n- ヘキシロキシ)-ベンゾール、たとえばS-811（メルクジャパン社製）、右回りカイラル剤に4-シアノ-4′-(2-メチルブチル)-ビフェニール、たとえばCB-15（メルク・リミテッド社製）を挙げることができる。

【００４２】図１２（ａ）から図１２（ｆ）は上下基板１１、１２の表面の液晶分子の配向方向およびプレチルト角α_0が同一で、しかも液晶分子に捩じれのない状態において、電極形状がそれぞれ異なる場合の分子配列への影響を示すので、図１２（ａ）ないし図１２（ｃ）は電圧無印加時の状態、図１２（ｄ）ないし図１２（ｆ）は電圧印加時の状態を表している。ここで、図１２（ａ）および図１２（ｄ）は上下基板の電極形状が等しく液晶層厚方向にのみ電界が印加される状態を示している。液晶分子は基板と平行になる分子の位置d_0を液晶層厚ｄの中点に有しており、図１２（ｄ）に示すように電極１３、１４に電源v_0から電圧を印加しても、その位置は変わらない。図１２（ｂ）は下基板１２の電極１４を図中左半分に形成し、右半分は無電極領域とし、上基板１１の他方の電極１３は図中右半分に形成し、左半分は無電極領域としたもので、相互の電極１３、１４は無電極領域に対面している。

【００４３】電圧v_0を印加すると、電極の相互のずれのために、液晶層に横電界成分をもつ電界が加わり、図示の右上がりの矢印E_R成分をもつ電気力線ｅが発生するため、図１２（ｅ）に示すように、分子Ｍは急峻な右上がりの分子配列になる。

【００４４】一方、図１２（ｃ）は下基板１２の電極１４を図中右半分に形成し、左半分は無電極領域とし、上基板１１の他方の電極１３は図中左半分に形成し、右半分は無電極領域としたもので、相互の電極１３、１４は無電極領域に対面している。図１２（ｆ）のように電圧v_0を印加すると、電極の相互のずれのために、液晶層に横電界成分をもつ電界が加わり、図示の左上がりの矢印E_L成分をもつ電気力線ｅが発生するため、液晶分子Ｍの向きは急峻な左上がりの配列になる。すなわち、電圧印加時の液晶分子の配列は横電界の形成に依存する。

【００４５】そこで、本実施例を示す図１（ａ）のように、上電極１３を複数のストライプ状導電体部１３ａを非導電体部１３ｂを介して等間隔に配置した電極パターンとし、同様に下電極１４を複数のストライプ状導電体部１４ａを非導電体部１４ｂを介して等間隔に配置したパターンとして、これら電極を相対向させたときに、一方の電極の導電体部１３ａまたは１４ａが他方の電極の非導電体部１４ｂまたは１３ｂに対向するように基板間に間隙を形成するように重ねる。この場合、上下基板の液晶配向方向が同一方向になるようにラビング処理しておく。この結果、無電圧印加時は、液晶はスプレイ配列状態を整然と保持するが、電圧印加時は導電体部が上下電極でずれているために、電極間に横電界成分をもつ斜め電界が発生し、図示のように交互に傾斜方向を変えた電気力線ｅを形成する。液晶分子Ｍは電気力線に沿って起き上がり配列するから右上がり斜め電界と左上がり斜め電界との境界で液晶配列が不連続となり、ウオールラインＤＬが発生する。

【００４６】一画素内で電極の導電体部と非導電体部を微細に多数形成すれば液晶分子の起き上がる方向が微細に分割されるから、一画素内に多数のウオールラインを発生することができて、この部分で光散乱を起こさせることができる。光散乱領域は境界部を中心に幅 5ないし30μm であるので、微細な領域の大きさをこの値の範囲で一致させるように、またはそれよりも小さい値になるように分割すれば一画素全面において光を散乱することができる。具体的には導電体部の最も広い部分の幅を50μm 以下、非導電体部の最も広い部分の幅を50μm 以下とするのが好ましい。また電圧を印加していない状態では液晶分子は全面連続的な配列をなすので、光透過状態を得ることができる。したがって、本発明によれば、電圧無印加時に光透過状態、電圧印加時に光散乱状態を得る電界制御を行うことができる。

【００４７】ここで、本発明は印加される電界の方向によって、液晶分子の傾く方向を制御しているので、上下基板のプレチルト角が等しいことが望ましく、実用的には上下基板のプレチルト角の差を 0.5° 以下にすることが望ましい。

【００４８】微視的に見ると、各領域における分子配列変化は、分子配列の変化に等しく応答速度はこれに準じた値をとるため、応答速度は従来のユニフォームツイスト配列のＴＮ－ＬＣＤやＳＴＮ－ＬＣＤ、ホモジニアス配列ＬＣＤよりもさらに速いことがわかっており、したがって、本発明のＬＣＤも極めて速い応答速度を得ることになる。

【００４９】また、本発明のＬＣＤは僅かな液晶分子配列変化によって光透過状態と光散乱状態の 2状態を得るので、電気光学特性にヒステリシスを生じない。

【００５０】また、液晶の捩じれ角度（ 0° を含む）の違いによって、前述の領域の境界の分子配列状態の組み合わせも異なるため、種々の組み合わせが可能となり、電気光学特性の急峻なものや、なだらかなものなど、種々実現可能である。ただし、捩じれ角を 270° よりも大きくすると、電圧印加状態から無印加状態に切り換えた時、電圧印加状態の分子配列をメモリーすることがある。これは結果的に電気光学特性にヒステリシスを生じさせることとなるので好ましくない。したがって、本発明のＬＣＤの液晶の捩じれ角は 0° ないし 270° とするのがよい。

【００５１】また、本発明のＬＣＤを捩じれ角 0° で作成し、直交した 2枚の偏光板間に各ラビング方向（セル平面で考えて上下基板で同一方向である）と一方の偏光板の吸収軸が平行となるように組み合わせると、散乱光源を用いた場合でも透過型のディスプレイとなり得る。

この場合、複屈折効果を利用した光学モードとなり、前述した透過率は低下するが、光透過状態を液晶層の光散乱状態によって実現するため視角依存性が少ないといった効果を得る。特に、階調表示をした際に表示が反転するような現象が生じないため、直視型のディスプレイとして、従来のＴＮ－ＬＣＤ等より優れた表示特性を得ることができる。

【００５２】また、本発明のＬＣＤは、液晶層の光散乱状態を僅かな液晶分子配列変化によって実現することができるので、印加電圧は極めて小さい値となる。よって、低電圧駆動が可能となるといった利点も得ることができる。

【００５３】つぎに請求項５に示す本発明のいくつかの実施態様のＬＣＤの電極構造、分子配列構造を図１３（ａ）から図１３（ｃ）、図１４（ａ）から図１４（ｃ）および図１５（ａ）から図１５（ｃ）により説明する。図１３（ａ）、図１４（ａ）および図１５（ａ）は電極構造の概略を示す斜視図であって、図１３（ｂ）、図１４（ｂ）および図１５（ｂ）は電極構造の概略を示す断面図、図１３（ｃ）、図１４（ｃ）および図１５（ｃ）は電界を印加した状態での液晶分子配列の概略を示す断面図である。

【００５４】また、図１６は請求項８のＬＣＤの構造を図１３（ｃ）、図１４（ｃ）および図１５（ｃ）に示した実施例に適用した場合の素子の断面構造を示した図である。

【００５５】各図において、ガラスなどからなる上下の基板１１、１２の各対向面にそれぞれ 1画素単位毎にストライプ状の上下電極１３、１４が配置される。矢印Ｆは上基板１１のラビング方向、矢印Ｒは下基板１２のラビング方向を示し、点線ｅは電源２１（図１３（ａ））から上下電極１３、１４に電圧を印加した時に生じる電気力線であり、Ｍはその時の液晶分子の配列を示す。ＤＬは発生したウォールを示している。

【００５６】図１３（ｂ）、図１５（ｂ）において、上基板１１側から基板法線方向に見た時の上電極１３の幅をＦＥ、下電極１４の幅をＲＥ、これらの電極間の隙間幅をＳＳとする。さらに、図１４（ｂ）において、上基板１１側から基板法線方向に見た時の上電極１３が下電極１４と重ならない部分の幅をＦＥ、下電極１４が上電極１３と重ならない部分の幅をＲＥ、これらの電極の重複している部分の幅をＥＥとする。また、いずれの図においても基板間間隙剤（スペーサ）等、本発明の特徴に直接関係しない部材は省略してある。

【００５７】さらに、本発明の図１３（ａ）から図１５（ｃ）、および図１（ｂ）はともに液晶の分子配列がいわゆるスプレイ配列とした場合の形状を示してある。図１の構成は、図示のように上下基板間で導電部と非導電部が互いに対向し、かつ両基板において前記導電部と非導電部が交互に配列された構造となっている（こうした電極構成を「入子」と定義する。）。

【００５８】図１３（ａ）から図１５（ｃ）を図１（ｂ）と比較してわかるように、本発明の電極構造は、図１（ｂ）に示す「入子」の電極構造に対し、図１３（ｂ）に示す構成は、上下基板間で導電部と非導電部が互いに対向している部分（ＦＥやＲＥの部分）の間に、上下基板とも非導電部となっているところ（ＳＳの部分）を設けた電極構造になっている。よって、このように図１３（ｂ）に示すように上下基板の電極構造の断面形状が、前記ＦＥ・ＳＳ・ＲＥ・ＳＳ・ＦＥ・ＳＳ・ＲＥ・ＳＳ・ＦＥ・ＳＳ・…といった順で配列していることから便宜上、こうした電極構成を「隙間付き入子」と定義する。

【００５９】また、図１４（ｂ）に示すものは上下基板間で導電部と非導電部が互いに対向している部分（ＦＥやＲＥの部分）の間に上下基板とも導電部となっている重なったところ（ＥＥの部分）を設けた電極構造となっている。よって、このように図１４（ｂ）に示すように上下基板の電極構造の断面形状が、前記ＦＥ・ＥＥ・ＲＥ・ＥＥ・ＦＥ・ＥＥ・ＲＥ・ＥＥ・ＦＥ・ＥＥ・…といった順で配列していることから便宜上、こうした電極構成を「重複入子」と定義する。

【００６０】また、図１５（ｂ）に示すものは、図１３（ｂ）の電極構造の変化形であり、素子平面方向での電極形状がいわゆるストライプ状の形状をなしている場合の電極構造である。つまり、図１５（ｂ）に示す電極構造は導電部と非導電部の形状が直線形状をなして平行配列している場合の電極構造を描いたものである。同様の形状は図１４の重複入子に対しても考えられるが、ここでは図示を省略する。こうした、「隙間付き入子」、「重複入子」の電極構造であり、かつ素子平面方向での電極形状がいわゆるストライプ状の形状をなしている場合の電極構造を、便宜上、「隙間付きストライプ入子」、「重複ストライプ入子」と定義する。

【００６１】逆に言えば図１４（ａ）に示すように、本発明にて提案するＬＣＤは液晶分子配列が前述した特徴を有しており、これに分子のチルト方位を著しく異ならせる部分を多数設けるような電極構造であれば、電極構造の平面的形状は図１５（ａ）のような整然としたストライプ形状にこだわる必要がないことを示している。にもかかわらず、図１５（ａ）のような「隙間付きストライプ入子」、「重複ストライプ入子」の電極構成を本発明の特徴の一つとしたのは、こうした電極構成が図１４（ａ）と異なった特徴を有することを見出だしたからである。

【００６２】さて、これら、４つの特長をもった電極構成のそれぞれの特長、およびその作用を説明する。図１３（ｂ）および図１５（ｂ）に示す「隙間付き入子」、「隙間付きストライプ入子」はＳＳで示す非導電部を有する分、「入子」と比較して斜め電界強度が弱くなる。

このことは、実用的に駆動電圧を若干高める半面、電気光学特性をなだらかな曲線にする。よって、きめ細かな階調表示をする場合に駆動が容易となる。また、ＳＳで示す非導電部を有する分、電極の上下基板間のアライメント（合わせ）にマージンを設けることができ、生産性が著しく向上する。また、図１４（ｂ）に示すような「重複入子」、および「重複ストライプ入子」は「隙間付き入子」、「隙間付きストライプ入子」や「入子」と比較して低い印加電圧にて斜め電界を得ることができる。よって、実用的に駆動電圧を低くすることができる。しかし、法線方向にかかる電界成分がＥＥの部分に生じるため、若干光散乱強度が低くなる。しかしながら、「隙間付き入子」、「隙間付きストライプ入子」同様、ＥＥで示す導電部を有する分、電極の上下基板間のアライメント（合わせ）にマージンを設けることができ、生産性が著しく向上する。

【００６３】また、「隙間付き入子」、「重複入子」に比較して、「隙間付きストライプ入子」および「重複ストライプ入子」はウォール（図１３（ｃ）、図１４（ｃ）、図１５（ｃ）のＤＬで示した配向不連続点）の出現形状が図１７に示すようなギザギザ形状となる。この形状は直線形状と比較して光散乱強度を高めることとなる。こうしたギザギザ形状は電極パターンが整然としたストライプ形状である程、よりギザギザとなることを我々は種々の実験により確認している。このことから、これら「隙間付きストライプ入子」および「重複ストライプ入子」の電極構造は、結果的に強い光散乱強度を得るといった特長をもつ電極構造であるといえる。

【００６４】以上説明してきたように、これら種々の電極構成は、それぞれ特長を有し、前述した従来の問題点を解決しうる手段であるわけである。ここまでの説明では液晶の分子配列は捩じれを有さないスプレイ状の分子配列にて説明したきたが、前述したように液晶分子のチルト方向が 2以上の自由度をもつ分子配列であれば、同様の効果を得ることは言うまでもない。

【００６５】さて、これらの本発明の種々の電極構成、分子配列にて前述したようなウォールを発生させた場合、斜め電界が微細な領域毎に相反するように構成されているため、電圧を印加しつづけても液晶分子は、ウォールが発生した状態の分子配列を維持しにくい。液晶分子配列というものはあまり微細に配列形状を変化させることが困難であるからである。つまりは、電界、磁界等の外力のみでは、こうした困難な分子配列形態を維持する力が不足していることになる。こうした問題を解決するために、両基板間隙に液晶層厚方向の長さが液晶層厚ｄより短い微粒子を混入させる。もしくは、液晶層厚方向の高さが電極間隔Ｄ（この間隔は実質的に液晶層厚ｄに等しい）より低い突起を前記両基板の少なくとも一方に設けると解決することを我々は見出だした。

【００６６】図１６はこの構成の概略を示す。図示するように、液晶層厚ｄより小さい微粒子２２を加えた構造からなる。このように、液晶層２０中に微粒子、突起を設けた場合、前記ウォールの出現場所にこの微粒子、突起があれば、これらの存在によって、前述した微細に配列形状を変化させ分子配列状態、つまりはウォールを多数出現させた分子配列状態を維持することを見出だした。こうした微粒子、突起が、多数のウォールを維持する機能をもつことから「ウォール支持体」と称する。このような機能を得る手段としては、本発明に示した方法の他、液晶層厚に等しい大きさの微粒子を前記液晶層内に必要以上に混入させる（つまりは基板間隙剤の混入）ことによっても得られる。しかしながら、この場合、多数のウォールを維持するためには、多数の基板間隙剤を混入させる必要が生じ、光透過状態を得る時に悪影響を及ぼす。具体的に述べると基板間隙剤による光散乱、および基板間隙剤表面の液晶分子配向による光散乱の影響である。本発明ではこれらの影響を低減させるため、前記ウォール支持体として、液晶層厚ｄより小さいことを特徴とする微粒子、突起を用いることとした。このように液晶層厚ｄより小さい微粒子、突起を用いることによって、これらに起因した光散乱は問題のないレベルとすることができることを、発明者等は実験により確認している。

【００６７】なお、このウォール支持体の機能を得るものとして、前述した微粒子、突起の他に、ＴＦＴ、ＭＩＭ基板に必然的に設けられる段差（配線電極や半導体層の厚みにより生じる段差）自体も、前記段差近傍では同様の機能を得ることを確認している。

【００６８】さらに、図１８、図１９および図２０にその構成を示すように、上電極１３または上電極１３および突起上に上透光性絶縁膜１７、下電極または下電極および突起上に下透光性絶縁膜１８を形成することにより、電圧無印加時の透過率やコントラストを向上させることができる。なお、これら透光性絶縁膜上に配向膜１５、１６が形成される。ただし、図２０では下透光性絶縁膜を設けない。電極１３、１４はＩＴＯでできており、その屈折率は約 1.9で基板、配向膜、液晶層の約 1.5よりも高い。そこで、透光性絶縁膜の屈折率を電極材料の屈折率と同等またはそれに近い値に選定する。実用的には電極材料の屈折率の 0.9～1.1 倍にするのが好ましい。以下、その理由について説明する。図２１に示すように、ＩＴＯと他の材料すなわち基板１１、１２、液晶層２０の屈折率の差が大きい。一方、画素電極がＩＴＯ導電体部１３ａ、１４ａと非導電体部１３ｂ、１４ｂの微細な領域に分割されているため、画素電極内の導電体部と非導電体部の屈折率差から光路が重なり光の干渉が起こってしまう。したがって、このような光の干渉をなくすことができれば、電圧無印加時の透過率やコントラストを向上させることができる。

【００６９】光の干渉は、画素電極材料と他の材料の屈

折率の差が大きく、かつ画素電極内で導電体部と非導電体部が微細な領域に分割されているため、入射光が導電体部と非導電体部で屈折される度合いが違うことにより起こる。このため、画素電極間での光干渉を防ぐためには、画素電極内で導電体部と非導電体部とで入射光を同じように屈折させればよい。したがって、画素電極材料とほぼ同じ屈折率を持つ透光性絶縁膜を画素電極の上に塗布すれば、画素電極内の非導電体部に入射された光も導電体部に入射された光と等しく光が屈折されるために、光の干渉を抑制することができる。画素電極は透光性導電体、実用的にはＩＴＯで構成される。このため、ＩＴＯとほぼ同じ屈折率を持つ透光性絶縁膜を用いればよい。すなわち、電極材料の屈折率の 0.9～1.1 倍の範囲であれば、光干渉による透過率の低下はほぼ生じない。また透光性絶縁膜の厚さは、ＩＴＯなどの透光性電極層の厚さの 1/2以上であれば、十分な効果が得られる。

【００７０】

【実施例】以下、本発明のＬＣＤの実施例を図面を参照して具体的に説明する。

実施例１

図１（ａ）は本実施例の上下電極のパターンを示す斜視図、図１（ｂ）は電極を相対向させた液晶セルの略断面図である。ガラスでできた上基板１１の一方の面全面にＩＴＯでできた透明共通電極１３を形成し、その表面にポリイミドの上配向膜（AL-3046 、日本合成ゴム製）１５を積層する。他方のガラスでできた下電極１２の一面にＩＴＯでできた画素電極１４を形成し、その表面にポリイミドの下配向膜（AL-3046 、日本合成ゴム製）１６を積層する。 1画素の大きさが 300μm × 300μm である画素電極１４を画素単位でモザイク状に配置する。上下配向膜１５、１６のプレチルト角は 3° である。

【００７１】上電極１３は 1画素毎に幅20μm の複数のスリットすなわち非導電部１３ｂを有して幅20μm の導電部１３ａを40μm ピッチでストライプ状に配列したパターンであり、 1画素 300μm 幅の中に 6本の導電部１３ａを形成する。相対する下電極１４も同じく 20μm 幅の導電部１４ａと20μm 幅の非導電部１４ｂを等間隔で配置したパターンを有し、 300μm 幅内に 6本の導電部１４ａを形成する。

【００７２】これら電極の導電部は上下基板を相対させた状態で相互に20μm ずらしてあり、一方の電極の導電部１３ａまたは１４ａが他方の電極の非導電部１４ｂまたは１３ｂに対面する。下電極１４はＴＦＴスイッチング素子１９を有し、ゲート線２３と信号線２４に接続される。

【００７３】上下配向膜１５、１６の配向方向Ｆ、Ｒは図示のように電極の導電部に直交するように、かつ同一方向となるように設定する。また上下基板の間隙を 10μm とし液晶セルを形成する。この基板間隙に誘電率異方性が正のネマティック液晶（ZLI-3926、メルクジャパン製）を充填し、液晶層２０とする。この液晶は複屈折率（△ｎ）が0.2030と大きい。この複屈折率（△ｎ）が大きいことと、10μmと層厚の厚い液晶層を選択することによりＬＣＤの光散乱性を高めることができる。

【００７４】このようにして得られた本発明のＬＣＤにＴＦＴ１９を介して電源２１から電圧を印加して電気光学特性（透過率－印加電圧曲線）を測定した。電圧印加により、電極間に横電界成分をもつ電界が発生し、 1画素の微小な範囲で横電界成分の方向が変化するから、液晶層２０の液晶分子Ｍが電界に応じて配列を変化する。したがって、液晶配列の境に多数のウォールラインＤＬが発生して光散乱状態を作り出す。

【００７５】透過率－印加電圧曲線を求めるために、ＬＣＤにHe －Ne レーザー光を入射させ透過率を測定した。測定結果を図２３に示す。なお光のスポット径は2mm で、透過したレーザー光はＬＣＤから距離20cmのところにあるフォトダイオードにより検出した。また印加電圧は 0Vから徐々に 5Vまで増加させ、その後 5Vから徐々に 0Vまで減少させた。電圧を印加していない状態（ 0V印加）では透過率約80%と、明るい透過率特性を示した。また、印加電圧 2.8Vでは最小透過率0.4%と、良好な光散乱状態が得られた。また、図２３から明らかなように電気光学特性にヒステリシスは全くなかった。また、印加電圧 2.8Vおよび 0Vにて、応答速度を測定したところ立ち上がり7msec 、立ち下がり25msecと極めて速い値を得た。

【００７６】実施例２

図２２（ａ）および図２２（ｂ）に本実施例を示す。図２２（ａ）に示すように、上電極１３の導電部１３ｃおよび非導電部１３ｄと下電極１４の導電部１４ａおよび非導電部１４ｂとのパターンが 1画素内で直交している。この導電部のパターン以外は実施例１と同じ構成である。ここに実施例１と同番号の部分は同一部分を示す。ただし、液晶層は誘電率異方性が正の液晶（ZLI-3926、メルクジャパン製）に左捩じれのカイラル剤（S-811 、メルクジャパン製）を添加した液晶組成物を用いた。また図２２（ｂ）に示すように、上下基板の配向方向Ｆ、Ｒを 180° ずらし、液晶分子を 180° 捩じれのスプレイ配列とした。

【００７７】この構造においては、上下電極１３、１４の導電部１３ｃ、１４ａが重なる領域と、一方の電極の導電部１３ｃまたは１４ａが他の電極の非導電部１４ｂまたは１３ｄと対面する領域が生じる。しかし、電圧印加時に生じる横電界成分が複雑に発生して液晶分子配列を乱すように作用する。このため、 1画素の微小領域内で充分な光散乱を非常に速い応答性で得ることができる。

【００７８】実施例３

図２４（ａ）は本実施例において、電極を相対向させた

液晶セルの略断面図、図２４（ｂ）は 1画素領域の上電極パターンを、図２４（ｃ）は 1画素領域の下電極パターンを示す。図２４（ａ）および図２４（ｂ）に示すように、上基板１１として各画素に屈曲ストライプパターンの非導電部１３ｂと導電部１３ａからなるＩＴＯの共通電極１３を形成したガラス基板を用いる。なお、非画素部全域にクロムからなるブラックマトリクスを形成する。図２４（ａ）および図２４（ｃ）に示すように、下基板１２として各画素に屈曲ストライプパターンの非導電部１４ｂと導電部１４ａからなるＩＴＯの共通電極１４およびＴＦＴからなるスイッチング素子を形成したガラス基板を用いる。図２４（ｂ）に示す上電極パターンは、ストライプ延長方向に直交する方向の導電部の幅を５μｍ、導電部の山－山間の幅を10μｍ、非導電部の幅を10μｍとした。また図２４（ｃ）に示す下電極パターンは、導電部の幅を５μｍ、非導電部の幅を10μｍとした。

【００７９】この基板の電極パターン上に配向膜１５、１６（商品名SE-7120 、日産化学工業製）（プレチルト角の測定値 6° ）を形成し、その表面を図に示す方向Ｆ、Ｒにラビング処理を施す。ついで、下基板側に基板間隙剤として液晶層厚が 7.5μｍ となるよう微粒子（商品名ミクロパールＳＰ、積水ファインケミカル製）（粒径 7.5μｍ ）を分散密度 100個／mm^2 となるよう乾式散布法にて散布した後、これら基板間に誘電率異方性が正の液晶組成物（商品名ZLI-3926、メルクジャパン製）（△ｎ＝0.2030）を挟持して、前述した「隙間付き入子」の電極構成からなる本実施例のＬＣＤを得た。ここで、液晶層厚を厚くし、液晶組成物の誘電率異方性を大きくしたのは、光散乱状態における光散乱性を高めるためである。

【００８０】このようにして得られたＬＣＤにＴＦＴを介して電圧を印加して電気光学特性（透過率－印加電圧曲線）を実施例１に示す方法で測定した。測定結果を図２７に示す。電圧を印加していない状態（ 0V印加）では透過率約80%と、明るい透過率特性を示した。また、印加電圧 3.1Ｖ－ 3.9Ｖでは最小透過率 0.4%と、良好な光散乱状態が得られた。また、図から明らかなように電気光学特性にヒステリシスは全くなかった。また、印加電圧 3.1Ｖおよび 0Ｖにて、応答速度を測定したところ立ち上がり6msec 、立ち下がり18msecと極めて速い値を得た。

【００８１】つぎに、下基板のＴＦＴを介して電圧を印加して、前述したウォールの維持状態を偏光顕微鏡による分子配列観察および透過率測定による光散乱状態測定によって調べた。本実施例においては印加電圧 3.1Ｖを印加しつづけた場合、１時間経過しても初期のウォール配列を維持していることが確認された。

【００８２】実施例４

実施例３と同じ基板１１、１２を用い、配向膜１５、１６に垂直配向処理用の処理剤（商品名ODS-E(Octadecyltrietoxysilane アルコール溶液）、チッソ製）を用い、基板を垂直配向処理した。ここで垂直配向処理は前述のアルコール溶液に各基板を浸漬することによって行う。得られたプレチルト角は上下基板とも90° であった。液晶組成物として負の誘電率異方性を示すネマティック液晶材料（商品名ZLI-4850（△ｎ＝0.208 ）、メルクジャパン製）を用いること以外、実施例３同様の条件、材料にて本実施例のＬＣＤを得た。実施例３同様、諸特性を測定したところ、図２７に示すように実施例３とほぼ同等の優れた結果を得た。

実施例５

図２５（ａ）に上基板電極パターン、図２５（ｂ）に下電極パターン図をそれぞれ示す。上基板として非画素部全域にクロムからなるブラックマトリクスを形成し、波形ストライプの導電部１３ａとこれより幅狭の非導電部１３ｂを各画素毎に形成した共通電極１３をＩＴＯパターニングで被着したガラス基板を用いる。下基板として上基板の非導電部１３ｂよりも幅狭の非導電部１４ｂを有する導電部１４ａをもつ下電極１４とＴＦＴ（図示しない）からなるスイッチング素子付きガラス基板を用いた。ここに下基板を囲む領域１４ｃは配線、ＴＦＴ形成領域である。　これらの基板を用いて、実施例３同様の条件、材料を用いて前述した「重複入子」の電極構成からなる本発明のＬＣＤを作製した。実施例３同様の方法、条件にて、本実施例におけるＬＣＤの電気光学特性（透過率－印加電圧曲線）を測定した。図２７にその結果を示す。

【００８３】電圧を印加していない状態（ 0V印加）では透過率約80%と、明るい透過率特性を示した。また、印加電圧 2.5Ｖ－ 3.3Ｖと実施例３以上に低電圧にて最小透過率 0.5%と、良好な光散乱状態が得られた。また、図から明らかなように電気光学特性にヒステリシスは全くなかった。また、印加電圧 2.5Ｖおよび 0Ｖにて、応答速度を測定したところ立ち上がり5msec 、立ち下がり12msecと極めて速い値を得た。

【００８４】つぎに、本実施例のＬＣＤにＴＦＴを介して電圧を印加して、前述したウォールの維持状態を偏光顕微鏡による分子配列観察および透過率測定による光散乱状態測定によって調べた。本実施例においては印加電圧 2.5Ｖを印加しつづけた場合、１時間経過しても初期のウォール配列を維持していることが確認された。

【００８５】実施例６

図２６（ａ）に上基板電極パターン、図２６（ｂ）に下電極パターン図をそれぞれ示す。上基板として非画素部全域にクロムからなるブラックマトリクスを形成し、各画素毎に直線ストライプの導電部１３ａと非導電部１３ｂを形成した共通電極１３をＩＴＯのパターニングで形成したガラス基板を用いる。下基板として各画素毎に直線ストライプの導電部１４ａと非導電部１４ｂからなる

下電極１４と、ＴＦＴからなるスイッチング素子付きガラス基板を用いる。上下電極の導電部の幅は 5μｍ、非導電部の幅は10μｍである。

【００８６】これらの基板を用いて、実施例３同様の条件、材料を用いて前述した「隙間付きストライプ入子」の電極構成からなる本実施例のＬＣＤを作製した。実施例３同様の方法、条件にて、本実施例におけるＬＣＤの電気光学特性（透過率－印加電圧曲線）を測定した。図２７にその結果を示す。

【００８７】電圧を印加していない状態（ 0V印加）では透過率約80%と、明るい透過率特性を示した。また、印加電圧 3.2V－ 3.9Vにて最小透過率 0.2%と、実施例３以上の良好な光散乱状態が得られた。また、図から明らかなように電気光学特性にヒステリシスは全くなかった。また、印加電圧 3.2Vおよび 0Vにて、応答速度を測定したところ立ち上がり6msec 、立ち下がり18msecと極めて速い値を得た。 つぎに、本実施例のＬＣＤにＴＦＴを介して電圧を印加して、前述したウォールの維持状態を偏光顕微鏡による分子配列観察および透過率測定による光散乱状態測定によって調べた。本実施例においては印加電圧 3.2Vを印加しつづけた場合、 1時間経過しても初期のウォール配列を維持していることが確認された。

実施例７

実施例３同様の上下基板を用い、同様の方法、材料にて配向処理を施した後、上基板側に前述したウォール支持体として微粒子（商品名ミクロパール、積水ファインケミカル製）（粒径 5.0μｍ）を分散密度1000個／mm^2 となるよう乾式散布法にて散布し、以降の工程は実施例１同様の方法、材料にて本発明のＬＣＤを作製した。実施例３同様の方法、条件で諸特性を測定したところ、図２７に示すように実施例３とほぼ同等の優れた結果を得た。

【００８８】また、実施例３同様、ＬＣＤにＴＦＴを介して電圧を印加して、前述したウォールの維持状態を偏光顕微鏡による分子配列観察および透過率測定による光散乱状態測定によって調べた。本実施例においては印加電圧 3.1Vを印加しつづけた場合、 10 時間経過しても初期のウォール配列を維持していることが確認された。

【００８９】実施例８

図２８（ａ）は電極を相対向させた液晶セルの略断面図、図２８（ｂ）は 1画素領域の上電極パターンを、図２８（ｃ）は 1画素領域の下電極パターンを示す。上下基板の電極パターンは実施例３と同一である。上下両基板の画素電極１３、１４の上に透光性絶縁膜１７、１８として屈折率が 1.9の透光性絶縁材（商品名 RTZ-206、触媒化成工業製）をオーバーコートして 1.0μｍ 厚さの透光性層とし、図２８（ａ）に示す構成の基板を得た。この基板を用いて実施例３と同様の方法、条件でＬＣＤを得た。得られたＬＣＤの電気光学特性（透過率－印加電圧曲線）を実施例１に示す方法で測定した。測定結果を図２９に示す。

【００９０】電圧を印加していない状態（ 0V印加）では透過率約85%と、明るい透過率特性を示した。また、印加電圧 3.3Vでは最小透過率 0.4%と、良好な光散乱状態が得られた。また、図から明らかなように電気光学特性にヒステリシスは全くなかった。また、印加電圧 3.1Vおよび 0Vにて、応答速度を測定したところ立ち上がり6msec 、立ち下がり18msecと極めて速い値を得た。つぎに、下基板のＴＦＴを介して電圧を印加して、前述したウォールの維持状態を偏光顕微鏡による分子配列観察および透過率測定による光散乱状態測定によって調べた。本実施例においては印加電圧 3.1Vを印加しつづけた場合、１時間経過しても初期のウォール配列を維持していることが確認された。

【００９１】実施例９

実施例４に示す電極パターンを有する上下基板を用い、その画素電極上に屈折率が 1.90 の透光性絶縁材（商品名 RTZ-606、触媒化成工業製）をオーバーコートして 1.0μｍ 厚さの透光性層を有する基板を得た。この基板を用いて実施例４と同様の方法、条件でＬＣＤを得た。得られたＬＣＤの電気光学特性（透過率－印加電圧曲線）を実施例１に示す方法で測定した。測定結果を図２９に示す。

【００９２】図２９に示すように実施例８とほぼ同等の優れた結果が得られた。また、応答速度およびウォールの維持状態も実施例８とほぼ同等に優れていた。さらに、入射光に対しても電圧無印加時の電極による光干渉が生じず、電圧無印加時の透過率が向上し、コントラストの向上効果が見られた。

【００９３】実施例１０

実施例５に示す電極パターンを有する上下基板を用い、その画素電極上に屈折率が 1.90 の透光性絶縁材（商品名 RTZ-606、触媒化成工業製）をオーバーコートして 1.0μｍ 厚さの透光性層を有する基板を得た。この基板を用いて実施例５と同様の方法、条件でＬＣＤを得た。得られたＬＣＤの電気光学特性（透過率－印加電圧曲線）を実施例１に示す方法で測定した。測定結果を図２９に示す。

【００９４】図２９に示すように実施例８とほぼ同等の優れた結果が得られた。また、応答速度およびウォールの維持状態も実施例８とほぼ同等に優れていた。さらに、入射光に対しても電圧無印加時の電極による光干渉が生じず、電圧無印加時の透過率が向上し、コントラストの向上効果が見られた。

【００９５】実施例１１

実施例６に示す電極パターンを有する上下基板を用いる以外、実施例８と同様の方法、条件でＬＣＤを得た。得られたＬＣＤの電気光学特性（透過率－印加電圧曲線）を実施例１に示す方法で測定した。測定結果を図２９に

示す。

【００９６】図２９に示すように実施例８とほぼ同等の優れた結果が得られた。また、応答速度およびウォールの維持状態も実施例８とほぼ同等に優れていた。さらに、入射光に対しても電圧無印加時の電極による光干渉が生じず、電圧無印加時の透過率が向上し、コントラストの向上効果が見られた。

【００９７】実施例１２

実施例７に示す電極パターンを有する上下基板を用いる以外、実施例８と同様の方法、条件でＬＣＤを得た。得られたＬＣＤの電気光学特性（透過率－印加電圧曲線）を実施例１に示す方法で測定した。測定結果を図２９に示す。図２９に示すように実施例８とほぼ同等の優れた結果が得られた。また、応答速度およびウォールの維持状態も実施例８とほぼ同等に優れていた。さらに、入射光に対しても電圧無印加時の電極による光干渉が生じず、電圧無印加時の透過率が向上し、コントラストの向上効果が見られた。

【００９８】実施例１３

図３０に示すように、上基板１１上に上電極１３を、下基板１２上に下電極１４を実施例６に示す電極パターンにて形成した基板を用い、両基板の電極側の面上に粒径 1.5μm の微粒子２２（商品名ミクロパールＳＰ、積水ファインケミカル製）を分散密度 1000 個／mm^2 となるよう散布した。これらの電極および微粒子の上に、透光性絶縁膜（商品名 RTZ-206、触媒化成工業製）１７、１８をオーバーコートして両基板表面を凸凹面に仕上げた。この上下基板を用いる以外、実施例８と同様の方法、条件でＬＣＤを得た。得られたＬＣＤは、実施例８とほぼ同等の優れた電気光学特性、応答速度、ウォールの維持状態が得られた。また、透光性絶縁膜により、電極の導体部の切れ目が光学的に解消して光干渉を防止できた。

【００９９】実施例１４

図３１（ａ）は本実施例の電極を相対向させた液晶セルの略断面図、図３１（ｂ）は 1画素領域の上電極パターンを、図３１（ｃ）は 1画素領域の下電極パターンを図３１（ｄ）は電圧印加時の液晶分子配列を示す。上電極１３は図３１（ｂ）に示すようにＩＴＯベタ電極を用いた。非画素部を遮光するブラックマトリックスは設けていない。下電極１４は図３１（ｃ）に示すように 1画素の大きさが 30 μm × 40 μm であり、導電体部のＩＴＯが 4.5μm 幅で、非導電体部が 7μm 幅であるスプレイパターンを各画素毎に形成する。各画素毎にＴＦＴスイッチング素子１９を形成して 1280 × 1024 の画素数を有する下基板を得る。

【０１００】この基板の電極パターン上に配向膜１５、１６（商品名SE-7120、日産化学工業製）（プレチルト角の測定値 6° ）を形成し、その表面を図に示す方向Ｆ、Ｒにラビング処理を施す。ついで、下基板側に基板間隙剤として液晶層厚が 6.0μm となるよう微粒子（商品名ミクロパールＳＰ、積水ファインケミカル製）（粒径 6.0μm ）を分散密度 100個／mm^2 となるよう乾式散布法にて散布した後、これら基板間に誘電率異方性が正の液晶組成物（商品名ZLI-4792、メルクジャパン製）（△ｎ＝0.094 ）を挟持して本実施例のＬＣＤを得た。

【０１０１】本実施例のセル構成の特徴は、以下に説明する 3つの特徴で示される。第１に、電圧を印加していない状態で液晶分子配列が電極ストライプ方向と平行に配列していることである。つまり、電圧を印加した際の斜め電界方向と液晶分子配列が直交している。よって、電圧を印加すると液晶分子配列と直交した方位に斜め電界が形成され、液晶分子はこの方向にツイストしながらチルトすることになる。この結果、電圧を印加した状態での液晶分子配列は、断面よりみて図３１（ａ）、平面でみて図３１Ｄのようになる。このような液晶分子配列により、電極ストライプ方向およびその直交方向の偏光成分に対する屈折率は液晶分子の異常光屈折率n_eと常光屈折率n_oとが電極ストライプ方向の直交方向に規則的に交互に配列する。したがって、液晶層に回折格子が形成され平行光を散乱させることができる。

【０１０２】第２に、斜め電界を有効に得るために、対向配置された両基板の電極間隔ＤをＤ≧Ｓ／２ の関係を満たすようにしていることである。ここでＳは電極部における非導電体部の最も狭い部分の幅である。本実施例において、ストライプ電極パターン（図３１（ｃ））のパターン間の幅Ｓは 7μm であり、対向配置された両基板の電極間隔Ｄは 6μm であるので、上述の関係式を満足している。

【０１０３】第３に、液晶層の△ｎｄを 564nmに設定していることである。この値は上述の実施例よりも小さい。これは回折格子の光散乱効果が△ｎｄに依存するためである。回折格子の光散乱効果は、GALE,M.et al.:1979, J.appl.Photogr.Engng, 4,41 によると次式で示される。

$T = \cos^2(\pi \Delta n d / \lambda)$

ここで、Ｔは散乱される光の強度（入射光に対する強度）であり、λは入射光波長である。この式から回折格子の光散乱効果は△ｎｄに依存する。本実施例の液晶セルの構成では、印加電圧により、この△ｎｄが変化する。その変化幅は 0から設定した液晶層の△ｎｄ後の値（ 564nm）までである。また上式から回折格子の光散乱効果は△ｎｄに対して極値を持つ。したがって、設定した△ｎｄの値が上式の極値より著しく大きいと液晶セルの電気光学特性に極値が生じてしまう。これはアナログ信号を用いた階調表現を困難にする。このため、本実施例では、これを考慮して液晶層の△ｎｄを 564nmに設定した。このように、本実施例は他の実施例と同様に液晶分子配列が形成する屈折レンズ効果（前述したウォール配列：液晶層厚方向に液晶分子が連続的に傾きを変え屈

折率が連続的に変化することにより入射した光を屈折させる効果）に加え、明確に回折格子効果が得られる構造としている。

【０１０４】このようにして得られたＬＣＤにＴＦＴを介して電圧を印加して電気光学特性（透過率－印加電圧曲線）を実施例１に示す方法で測定した。測定結果を図３２に示す。電圧を印加していない状態（ 0V印加）では透過率約80%と、明るい透過率特性を示した。また、印加電圧 3.2V以上では最小透過率 0.2%と、良好な光散乱状態が得られた。また、図から明らかなように電気光学特性にヒステリシスは全くなかった。また、印加電圧 3.2Vおよび 0Vにて、応答速度を測定したところ立ち上がり7msec 、立ち下がり23msecと極めて速い値を得た。

【０１０５】実施例１５

配向膜として、垂直配向を示す配向膜１５、１６（商品名JALS-204-R14、（株）日本合成ゴム製）、液晶組成物として負の誘電率異方性を有する液晶組成物（商品名 ZLI-4318、メルクジャパン製）（$\Delta n = 0.1243$）を用いる以外は、実施例１４と同様の方法でＬＣＤを得た。

【０１０６】本実施例のＬＣＤの電圧無印加時および電圧印加時の平面的にみた液晶分子配列をそれぞれ図３３（ａ）、図３３（ｂ）に示す。電圧無印加状態（図３３（ａ））では、液晶分子は一様に配列（垂直配向）している。これに対して電圧印加状態（図３３（ｂ））では、ＩＴＯが上下基板で対向しているところではラビング方位にチルトダウンし、逆にＴＦＴ基板のＩＴＯがない領域では斜め電界が電極ストライプ方向と直交した方向に発生するため、その方向にチルトダウンする。よって図示するように本実施例のＬＣＤは実施例１４に示したＬＣＤ同様、電圧を印加した状態において電極ストライプ方向、およびその直交方向偏光成分に対する屈折率が液晶分子の異常光屈折率n_eと常光屈折率n_0が電極ストライプ方向の直交方向に規則的に交互に配列し、その結果、液晶層に回折格子が形成され、平行光を散乱させることができる。

【０１０７】本実施例は、実施例１４と同様に回折格子効果および屈折レンズ効果を得る構成となっており、実施例１４と比較して電圧無印加時の分子配列が逆（水平配向に対して垂直配向）であり、用いた液晶組成物の誘電率異方性も逆（正に対して負）としたものである。このように本発明のＬＣＤは電圧を印加した状態において電極ストライプ方向およびその直交方向の偏光成分に対する屈折率が液晶分子の異常光屈折率n_eと常光屈折率n_0が一定方向（一方向以上）に規則的に交互に配列するようにすれば、液晶層には回折格子が形成され、平行光を散乱させる効果を得ることができる。この効果を直交した 2方向の偏光成分に対して得るようにすれば、非偏光の光を散乱させることができ高いコントラスト特性が得られるようになる。こうした構成を実現させるには液晶分子のチルト方向（チルト方向およびチルトダウン方向）の自由度が無限大である初期垂直配向に誘電率異方性が負の液晶組成物を用いると容易に実現できる。

【０１０８】このようにして得られたＬＣＤにＴＦＴを介して電圧を印加して電気光学特性（透過率－印加電圧曲線）を実施例１に示す方法で測定した。測定結果を図３２に示す。電圧を印加していない状態（ 0V印加）では透過率約80%と、明るい透過率特性を示した。また、印加電圧 3.8V以上では最小透過率 0.2%と、良好な光散乱状態が得られた。また、図から明らかなように電気光学特性にヒステリシスは全くなかった。また、印加電圧 3.8Vおよび 0Vにて、応答速度を測定したところ立ち上がり10msec、立ち下がり20msecと極めて速い値を得た。

【０１０９】実施例１６

実施例１５で得られたＬＣＤを用いて投影型液晶表示装置を作製した。その構造を図３４に示す。メタルハライドランプ２５を光源とする光源光はシュリーレンレンズ２６により平行光とされ液晶セル２７、集光レンズ２８を経て投影レンズユニット３０によりスクリーン３１に投影される。駆動装置３２およびビデオ信号出力装置３３により液晶セル２７に入力された画像はスクリーン３１に拡大して表示される。本発明のＬＣＤは平行光の光路を直進または散乱と電界にて制御できるものである。よって図示するようにシュリーレン光学系を用いればスクリーン３１上に任意の画像表示ができることとなる。本実施例では液晶セル３１に入射させた平行光のうち直進した光のみを投影するために集光レンズ２８の焦点の位置に絞り（ 5mmφ）２９を設けて液晶セル３１で散乱させた光を遮断した構成としている。

【０１１０】得られた投影型液晶表示装置を用いてモノクロのビデオ信号画像を約 30 倍に投影したところコントラスト比は約 200：1 と極めて高い値であることがわかった。また、極めて明るい表示を得た。

【０１１１】実施例１７

実施例１５で得られたＬＣＤを 3枚用いて投影型液晶表示装置を作製した。その構造を図３５に示す。本実施例では光源としてＲＧＢの 3波長を含む白色光源３７を用いており、これをダイオクロイックミラー３４、３５および全反射ミラー３６を用いてそれぞれＲＧＢの波長に分光させ、 3枚の液晶セル２７ａ、２７ｂ、２７ｃに入射させている。こうすることにより、各波長毎に光路を制御することが可能となる。よって、カラー表示が実現できる。なお、ダイオクロイックミラー３４は赤の波長を透過させ、緑および青の波長を全反射させ、ダイオクロイックミラー３５は青の波長を透過させ、赤および緑の波長を全反射させる。

【０１１２】得られた投影型液晶表示装置を用いてフルカラーのビデオ信号画像を約 30 倍に投影したところコントラスト比は約 180：1 と極めて高い値であることが

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わかった。また、極めて明るい表示を得た。

【0113】実施例18

上基板として、カラーフィルター上にITOからなるべた電極を形成した、RGBからなるカラーフィルター付き基板を用いた以外は、実施例15と同様の方法でLCDを得た。このLCDを用いて実施例16と同様の構成にて投影型液晶表示装置を作製した。カラーフィルターを設けることによりカラー表示が実現できる。

【0114】得られた投影型液晶表示装置を用いてフルカラーのビデオ信号画像を約 30 倍に投影したところコントラスト比は約 160：1 と極めて高い値であることがわかった。また、極めて明るい表示を得た。

【0115】

【発明の効果】本発明のネマティック液晶層からなるLCDは、 1画素毎に画素内の一部の領域で導電体部と非導電体部とを対向させ、かつ非導電体部の最も狭い部分の幅をSとし、対向配置された両基板の電極間隔をDとしたとき、D≧S／2 の関係が満たされているので、一様な液晶分子配列とすることにより光透過状態を、 2種以上の方向の電界方向を印加することによる屈折レンズ効果や回折格子効果により光散乱状態を実現することができる。その結果、液晶以外の媒体を必要としないで、光散乱特性に優れたLCDが得られる。とくに、液晶層を形成する液晶分子が電圧無印加状態でスプレイ配列をなし、液晶層に電界を印加した際のチルト方向が 2方向以上取り得る分子配列の場合に優れた散乱特性が得られる。

【0116】本発明のLCDは、電極構造を「入れ子構造」、「隙間付き入れ子構造」、「重複入子」、「隙間付きストライプ入子」または「重複ストライプ入子」とすることにより、斜め電界を微細な領域毎に相反するように容易に形成することができる。その結果、光の散乱特性が高く、駆動電圧の低い、明るくコントラスト比の高い階調性に優れたLCDや、階調表示しても表示が反転する視角のない極めて広い視角依存性を有するLCDが得られる。

【0117】このような効果は、両基板間隙に電極間隔Dより短い直径を有する微粒子を混入させるか、または電極間隔Dより短い突起を両基板の少なくとも一方に設けることにより、実用的に維持することができる。さらに、電極上にこの電極材料の屈折率の 0.9～1.1 倍である透光性保護膜が形成することにより、電圧無印加時の透過率やコントラストを向上させることができる。

【0118】本発明の液晶表示装置は、とくに投影型液晶表示装置に上述のLCDを応用することにより、コントラスト比が極めて高い、また、極めて明るい表示を得ることができる。

【図面の簡単な説明】

【図1】本発明の一実施例を説明する図で、（a）は電極の斜視図、（b）は液晶セルの断面図である。

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【図2】本発明の電極構造を説明するための図である。

【図3】プレチルト角を説明するための図で、（a）は断面略図、（b）は平面略図である。

【図4】ユニフォーム配列を説明するための図で、（a）は平面略図、（b）は断面略図である。

【図5】電圧印加時のユニフォームツイスト配列の液晶分子の振る舞いを説明する断面略図である。

【図6】ユニフォームツイスト配列を説明する平面略図である。

【図7】印加電圧と透過率の関係を説明する曲線図である。

【図8】ユニフォームツイスト配列を説明する平面略図である。

【図9】スプレイ配列を説明するための図で、（a）は平面略図、（b）は断面略図である。

【図10】スプレイツイスト配列を説明する平面略図である。

【図11】スプレイツイスト配列を説明する平面略図である。

【図12】スプレイ配列の液晶分子の印加電圧の有無による振る舞いを説明する断面略図であり、（a）から（c）は電圧無印加時、（d）から（f）は電圧印加時を示す。

【図13】一実施例のLCDを説明する図であり、（a）は電極構造の斜視図、（b）は（a）におけるX－X′線に沿って切断して示す断面略図、（c）は電圧印加時の液晶分子の状態を示す略図である。

【図14】他の実施例のLCDを説明する図であり、（a）は電極構造の斜視図、（b）は（a）におけるX－X′線に沿って切断して示す断面略図、（c）は電圧印加時の液晶分子の状態を示す略図である。

【図15】他の実施例のLCDを説明する図であり、（a）は電極構造の斜視図、（b）は（a）におけるX－X′線に沿って切断して示す断面略図、（c）は電圧印加時の液晶分子の状態を示す略図である。

【図16】他の実施例のLCDを説明するもので、電圧印加時の液晶分子の状態を示す略図である。

【図17】図13（c）に示すウォールの出現形状を説明する平面図である。

【図18】一実施例のLCDを説明するもので、液晶セルの断面図である。

【図19】他の実施例のLCDを説明するもので、液晶セルの断面図である。

【図20】他の実施例のLCDを説明するもので、液晶セルの断面図である。

【図21】透光性の絶縁膜の作用を説明する図である。

【図22】一実施例のLCDを説明するもので、（a）は電極の斜視図、（b）は上下基板の配向方向を示す略図である。

【図23】実施例1の透過率－印加電圧曲線の関係を示

す図である。

【図２４】一実施例のＬＣＤを説明するもので、（ａ）は電極構造配置と液晶分子の状態を説明する略図、（ｂ）は上電極（共通電極）の平面図、（ｃ）は下電極の平面図である。

【図２５】他の実施例のＬＣＤを説明するもので、（ａ）は上電極（共通電極）の平面図、（ｂ）は下電極の平面図である。

【図２６】他の実施例のＬＣＤを説明するもので、（ａ）は上電極（共通電極）の平面図、（ｂ）は下電極の平面図である。

【図２７】実施例３から実施例７の透過率－印加電圧曲線の関係を示す図である。

【図２８】透光性の絶縁膜を用いたＬＣＤを説明するもので、（ａ）は電極構造配置と液晶分子の状態を説明する略図、（ｂ）は上電極（共通電極）の平面図、（ｃ）は下電極の平面図である。

【図２９】実施例８から実施例１２の透過率－印加電圧曲線の関係を示す図である。

【図３０】基板面上に微粒子を形成した実施例の電極構造配置と液晶分子の状態を説明する略図である。

【図３１】一実施例のＬＣＤを説明するもので、（ａ）は電極構造配置と液晶分子の状態を説明する略図、（ｂ）は上電極（共通電極）の平面図、（ｃ）は下電極の平面図、（ｄ）は液晶分子の状態を説明する略図である。

【図３２】実施例１４および実施例１５のＬＣＤの透過率－印加電圧曲線の関係を示す図である。

【図３３】実施例１５のＬＣＤを説明するもので、（ａ）は電圧無印加時の平面的にみた液晶分子配列を示す図、（ｂ）は電圧印加時の平面的にみた液晶分子配列を示す図である。

【図３４】実施例１６における投影型液晶表示装置を示す図である。

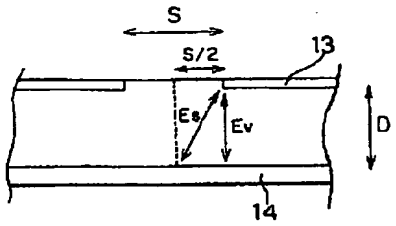
【図３５】実施例１７における投影型液晶表示装置を示す図である。

【図３６】従来のＬＣＤを説明するもので、（ａ）はカプセル状構造の断面略図を示す図、（ｂ）は繊維状ポリマー構造の断面略図である。

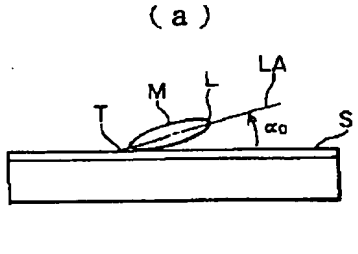
【符号の説明】

１、２……基板、３……ポリマー、４、６……液晶、５……繊維状ポリマー、１１……上基板、１２……下基板、１３……上電極、１４……下電極、１５……上配向膜、１６……下配向膜、、１７……上透光性絶縁膜、１８……下透光性絶縁膜、１９……スイッチング素子、２０……液晶層、２１……電源、２２……微粒子、２３……ゲート線、２４……信号線、２５……メタルハライドランプ、２６……シュリーレンレンズ、２７……液晶セル、２８……集光レンズ、２９……絞り、３０……投影レンズユニット、３１……スクリーン、３２……駆動装置、３３……ビデオ信号出力装置、３４、３５……ダイオクロイックミラー、３６……全反射ミラー、３７……白色光源。

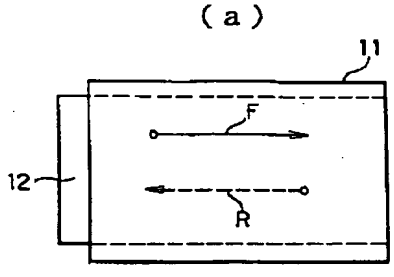
【図２】



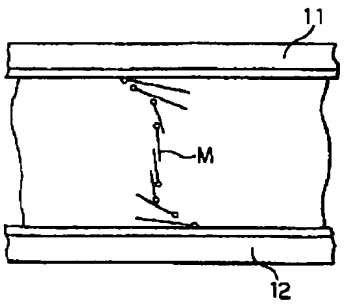
【図３】



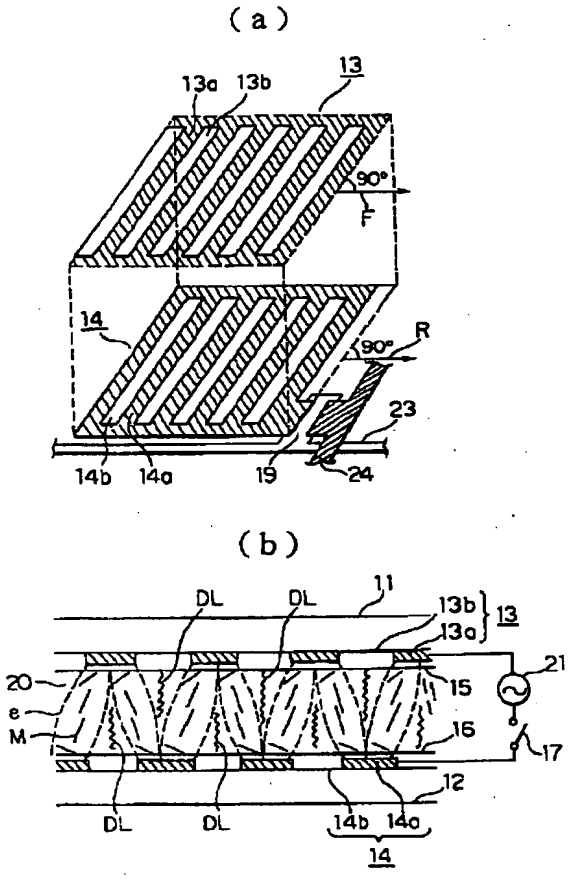
【図４】



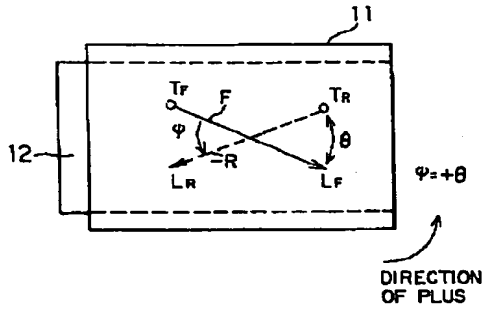
【図５】



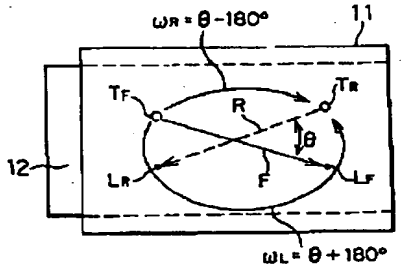
【図１】



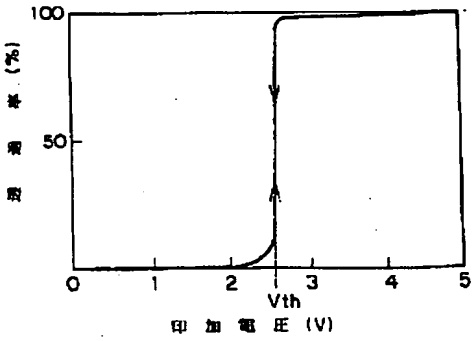
【図６】



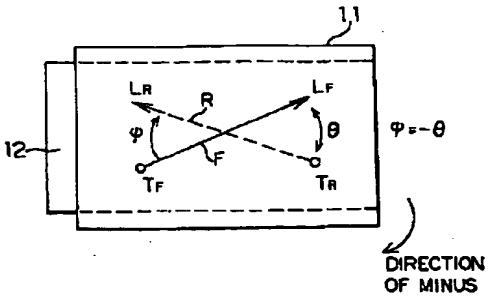
【図１０】



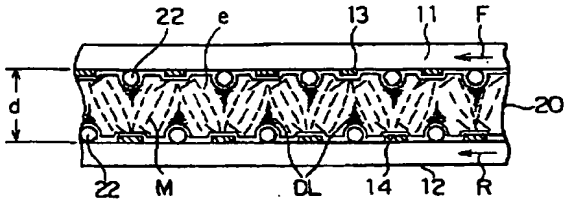
【図７】



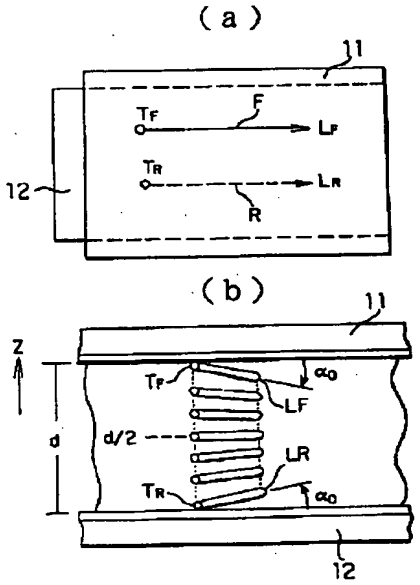
【図８】



【図１６】



【図９】



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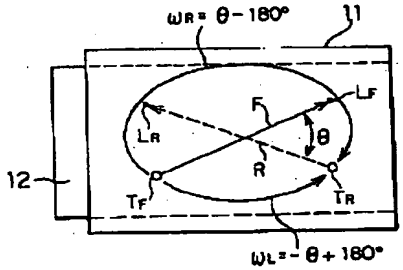

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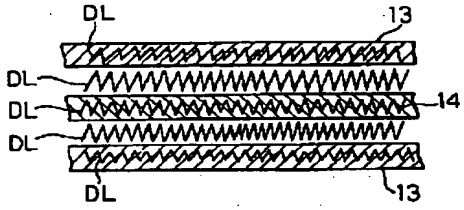

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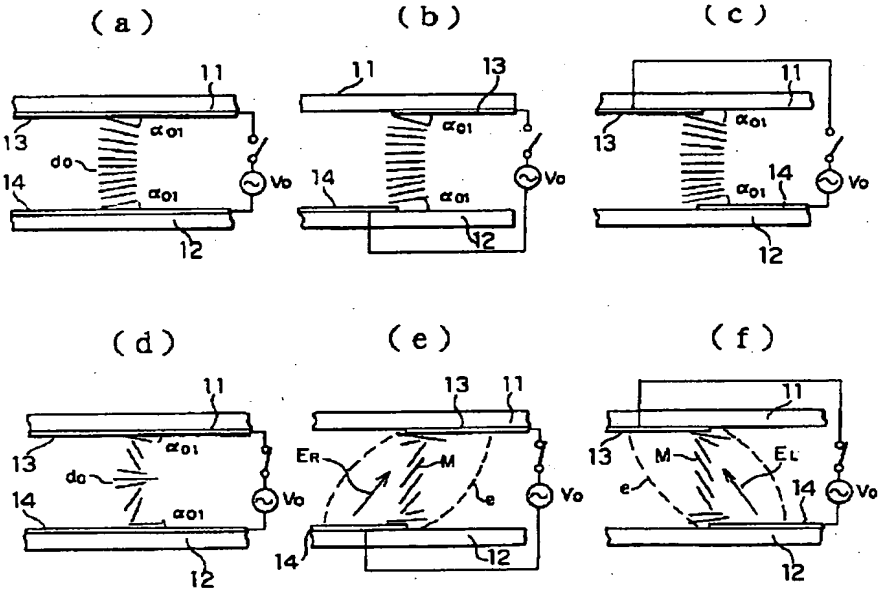

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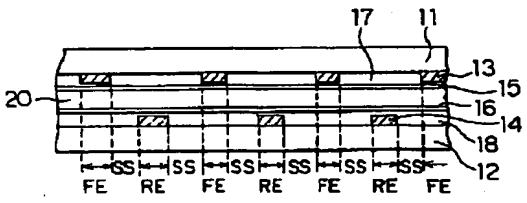

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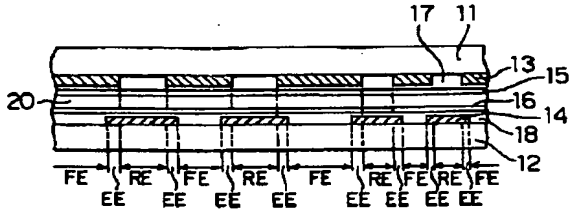

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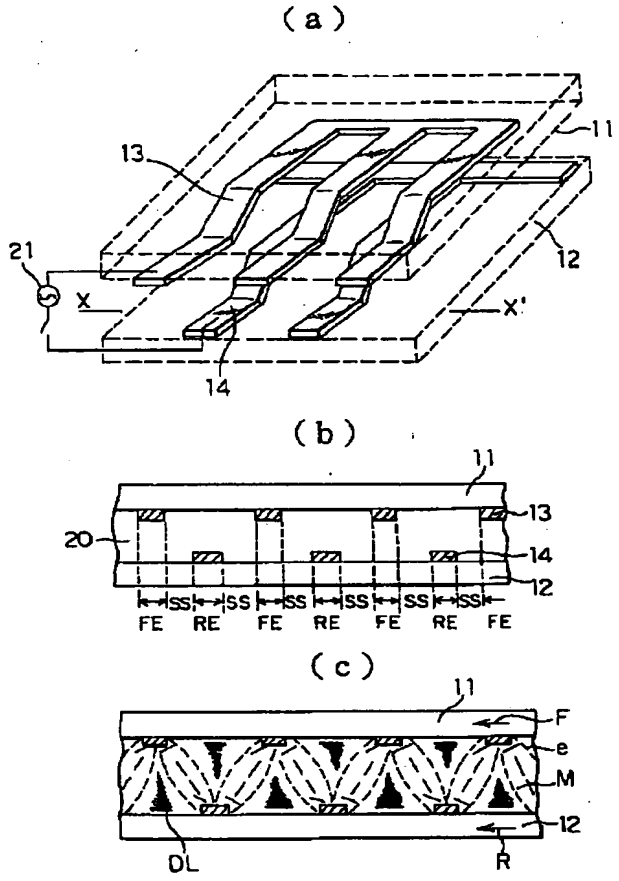

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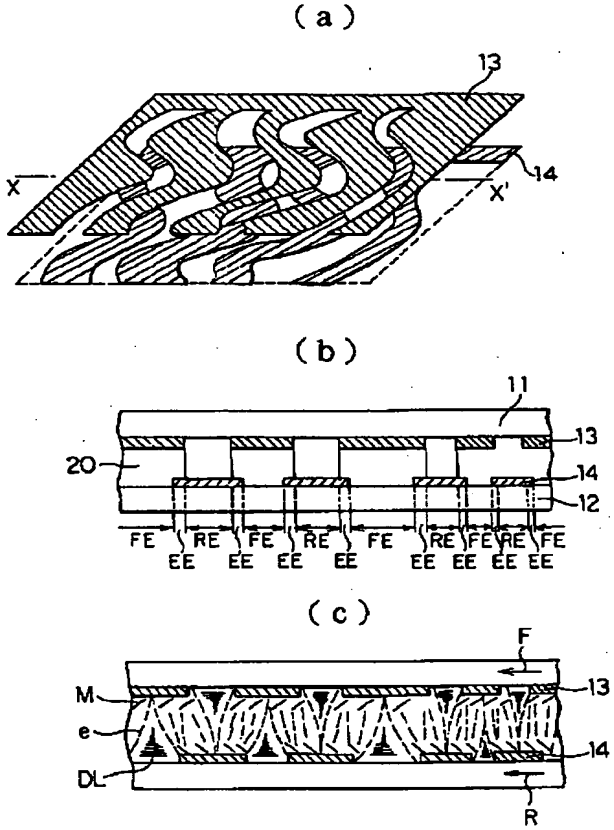

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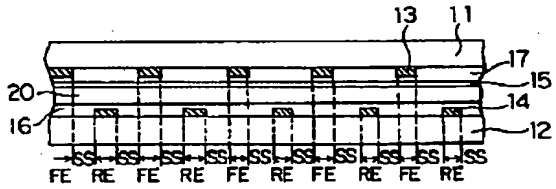

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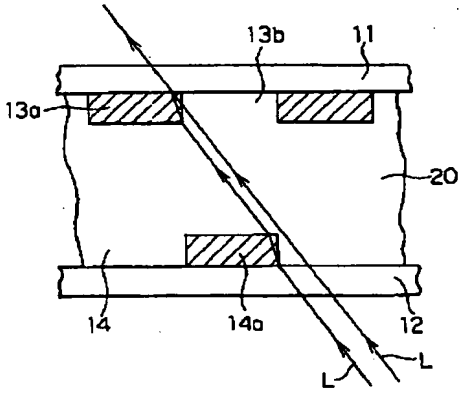

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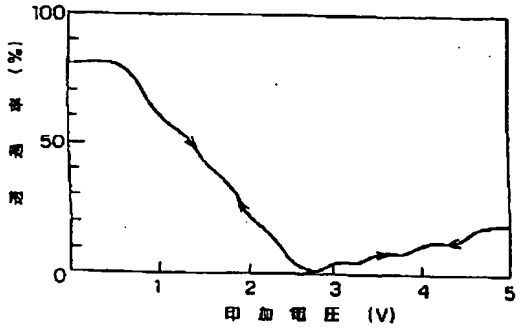

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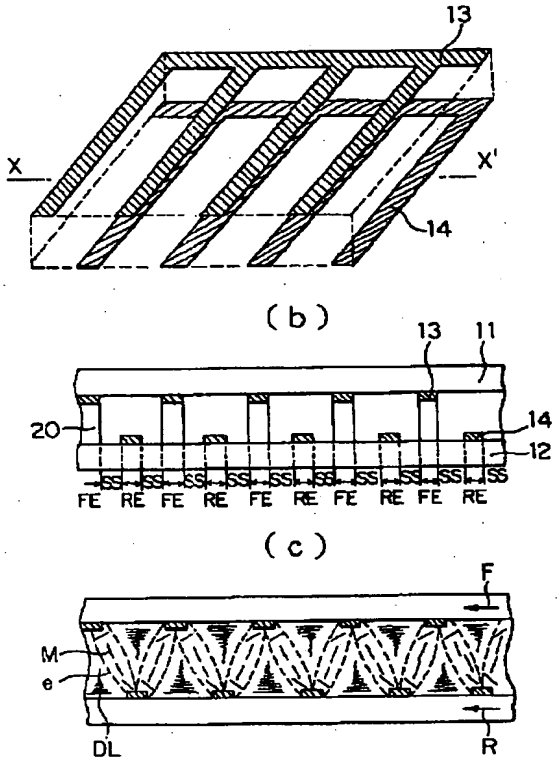

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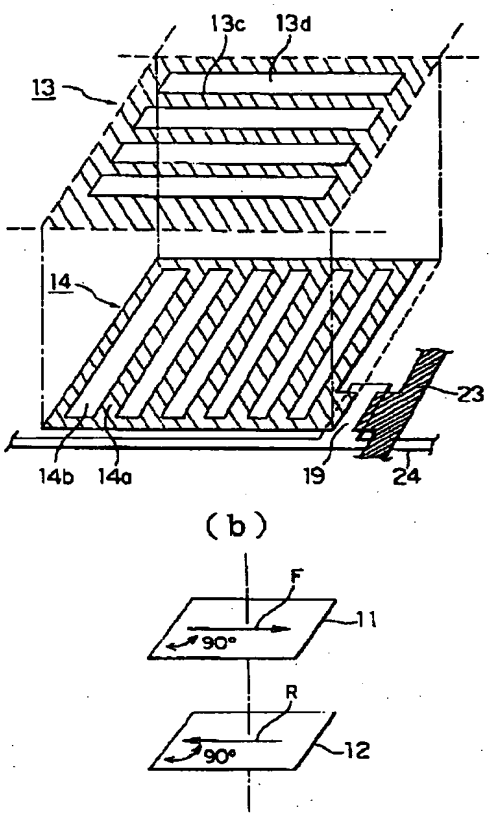

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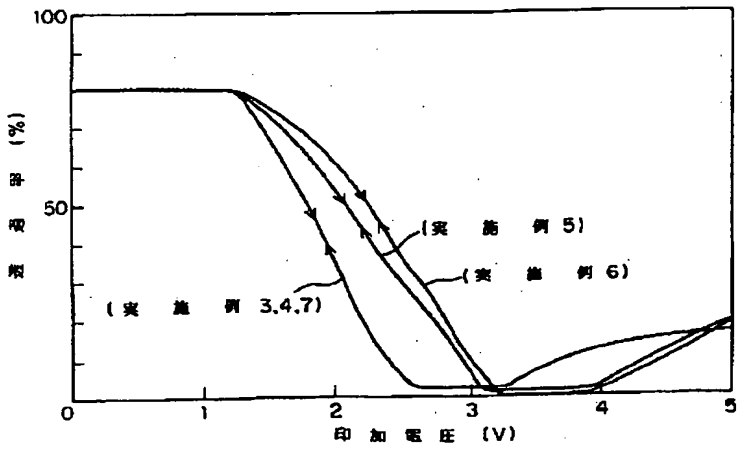

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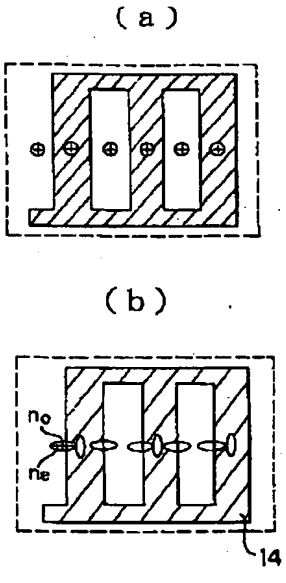

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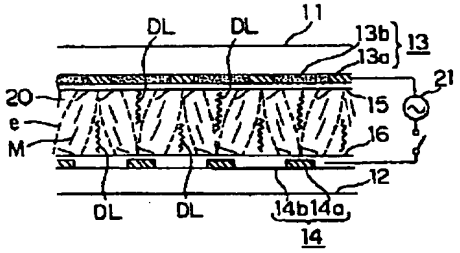

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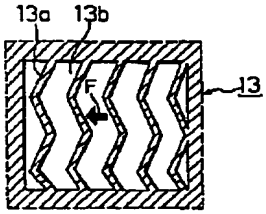

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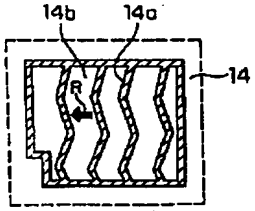

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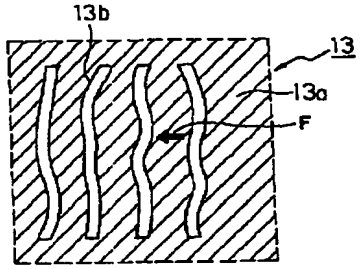

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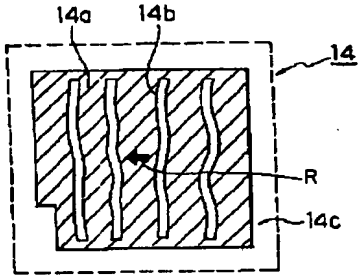

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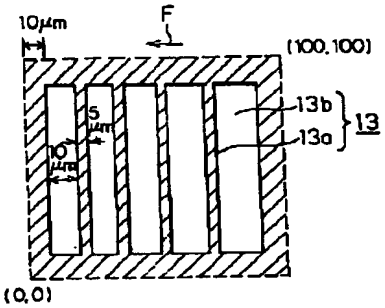

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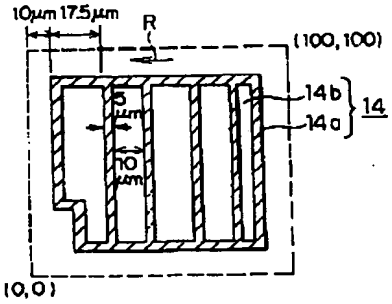

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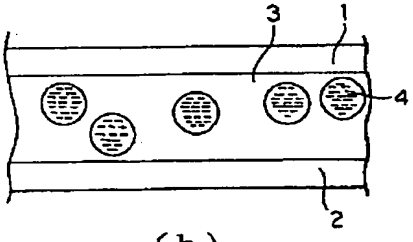

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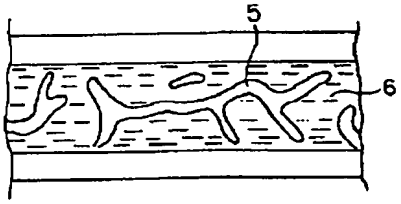

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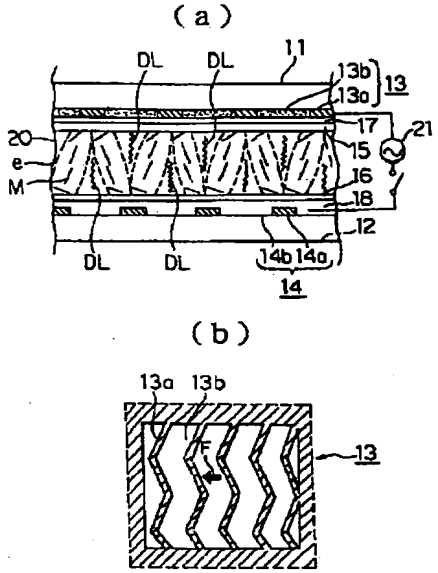

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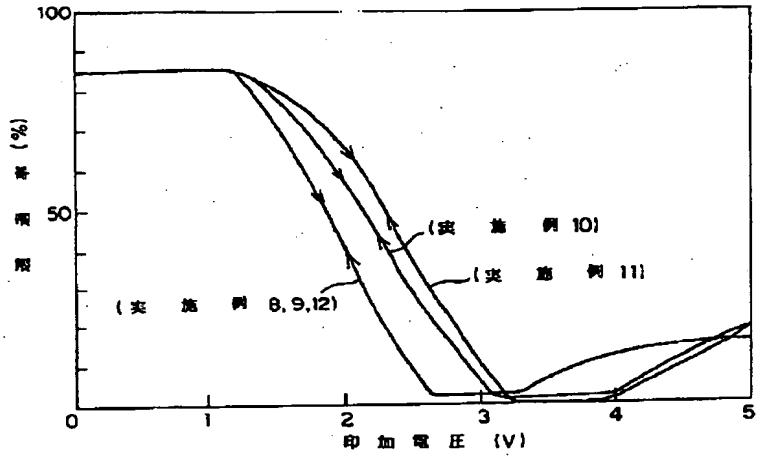

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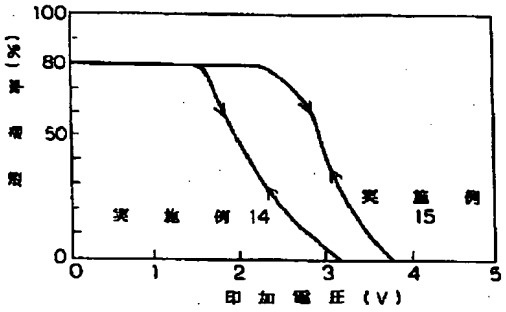

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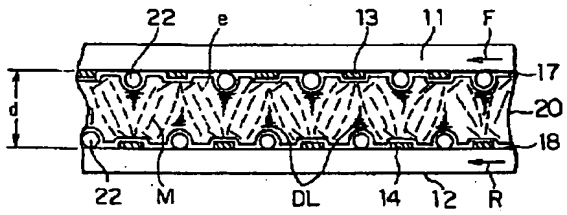

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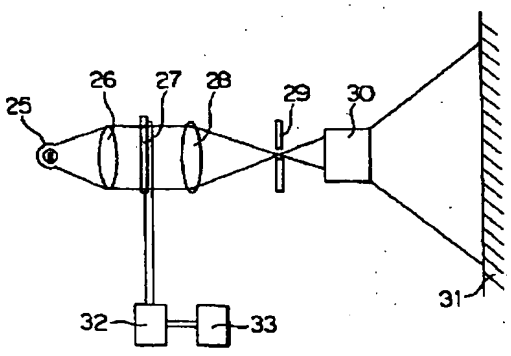

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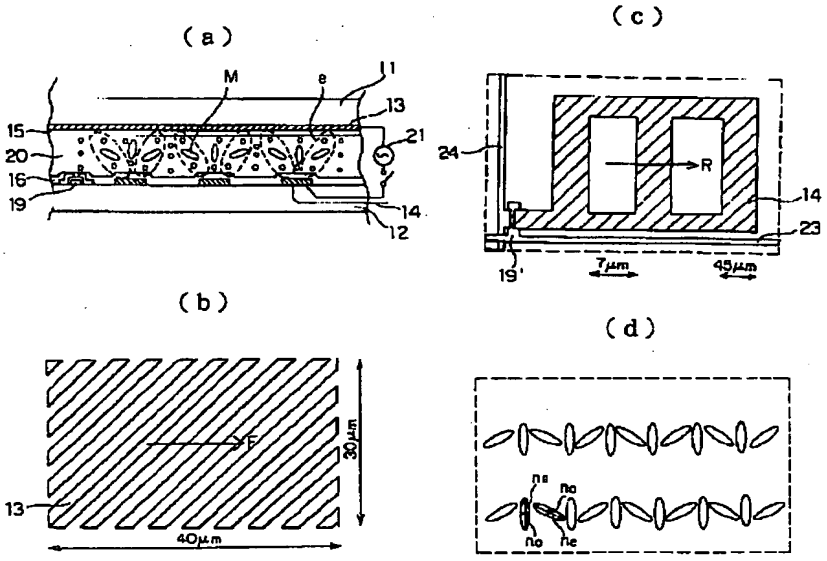

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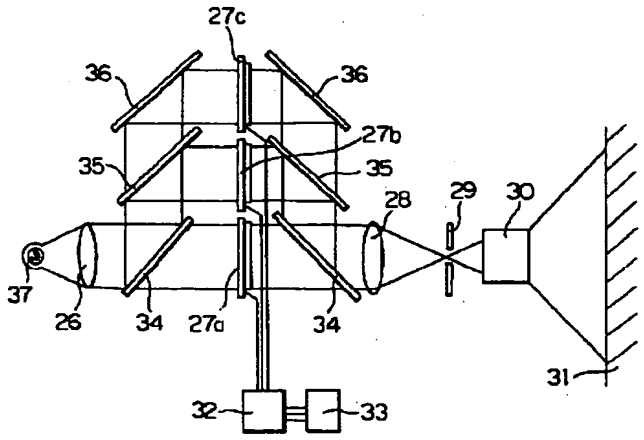

フロントページの続き

(72)発明者　羽藤　仁
神奈川県横浜市磯子区新杉田町８番地　株式会社東芝横浜事業所内

(72)発明者　岡本　ますみ
神奈川県横浜市磯子区新杉田町８番地　株式会社東芝横浜事業所内

(72)発明者　大山　毅
神奈川県横浜市磯子区新杉田町８番地　株式会社東芝横浜事業所内